TM55-1014

WAR DEPARTMENT TECHNICAL MANUAL

ENGINE, GASOLINE, MARINE, VIMALERT MODEL V-1150-1

WAR DEPARTMENT • 1 NOVEMBER 1944

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WAR DEPARTMENT
WASHINGTON 25, D. C., 1 November 1944

TM 55–1014, Engine, Gasoline, Marine, Vimalert Model V–1150–1, is published for the information and guidance of all concerned.

[A.G. 300.7 (18 Oct 44)]

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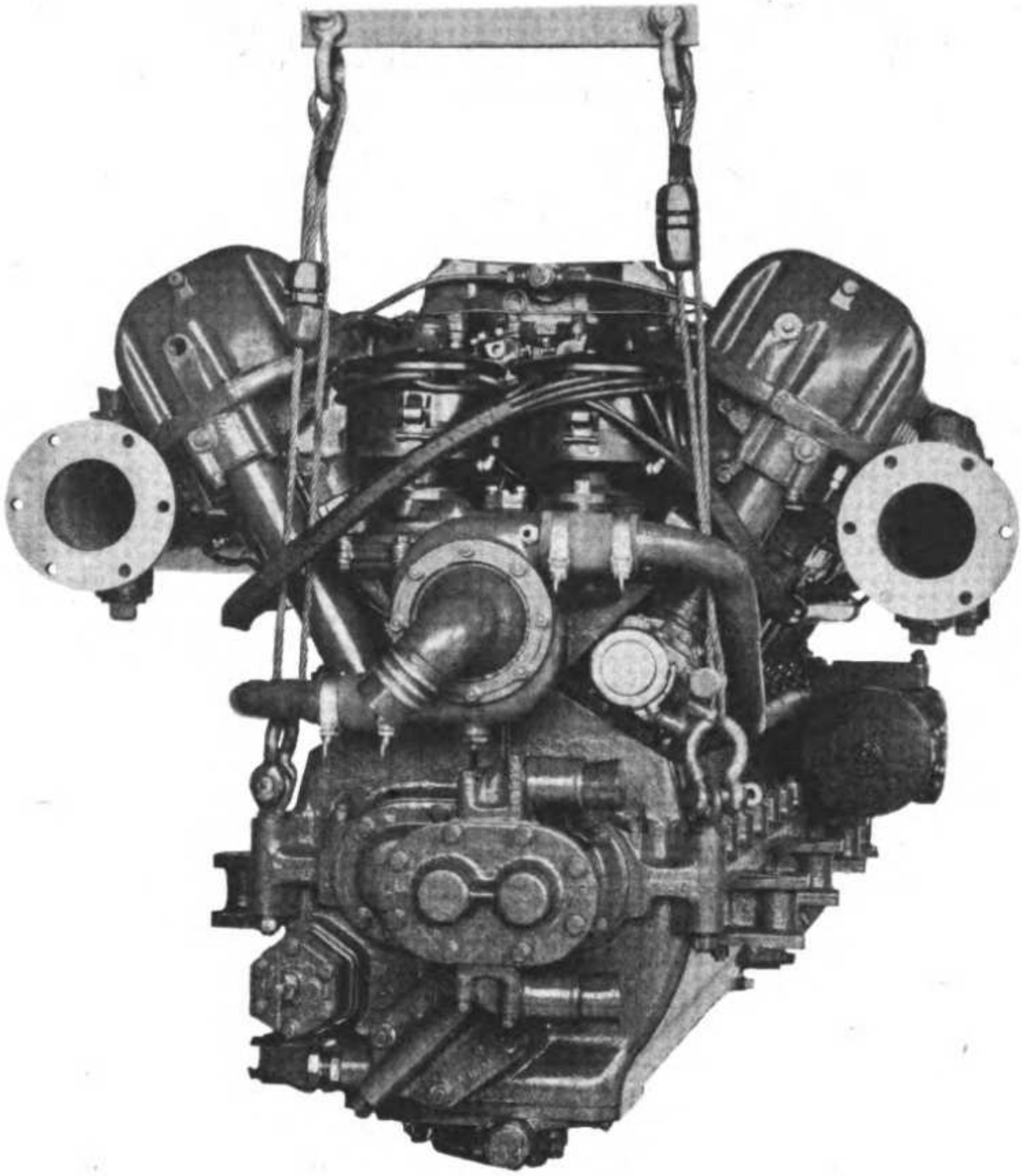
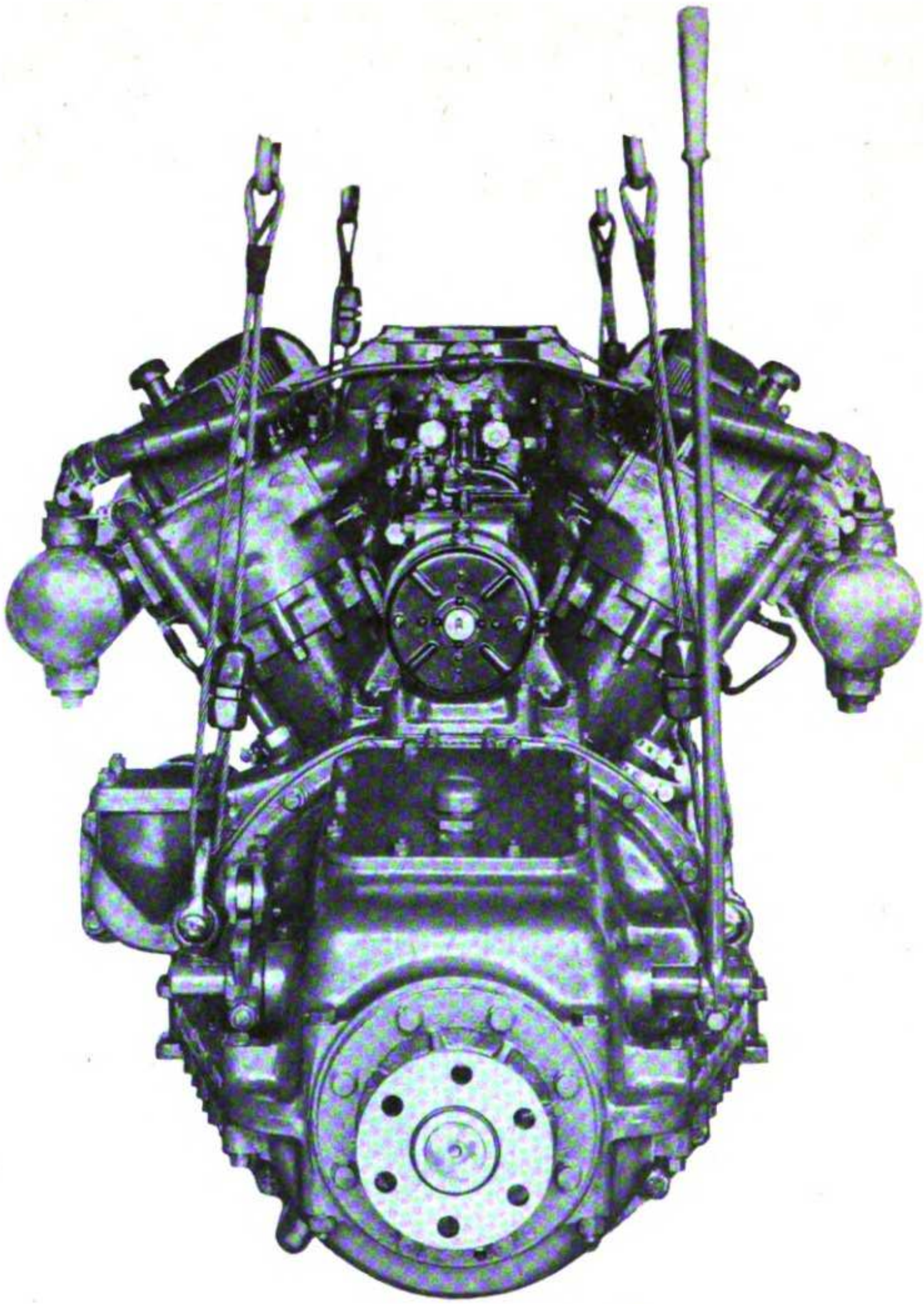


V-1150-1 ENGINE-FRONT VIEW



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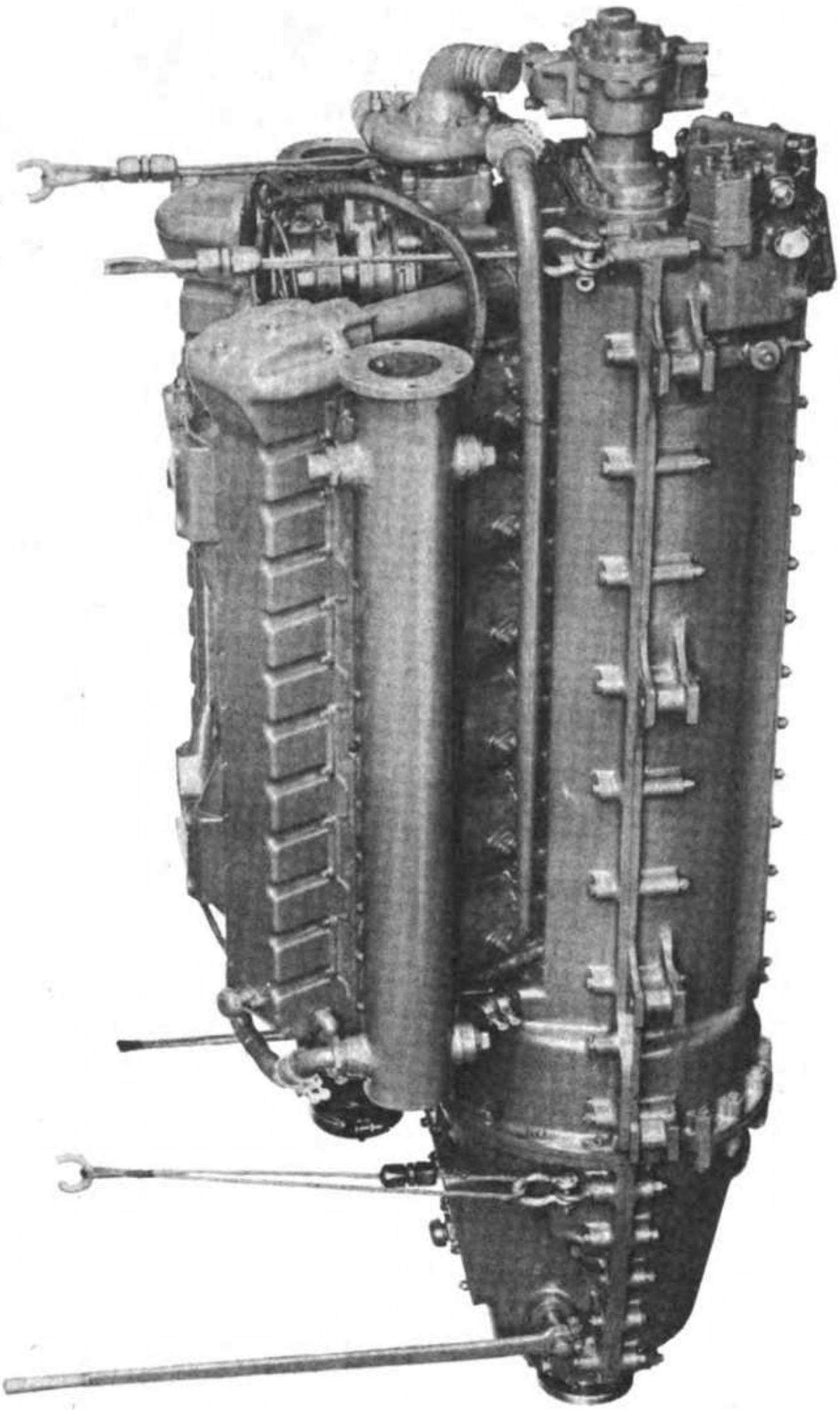


V-1150-1 ENGINE-SIDE VIEW

FULL POWER CALIBRATION

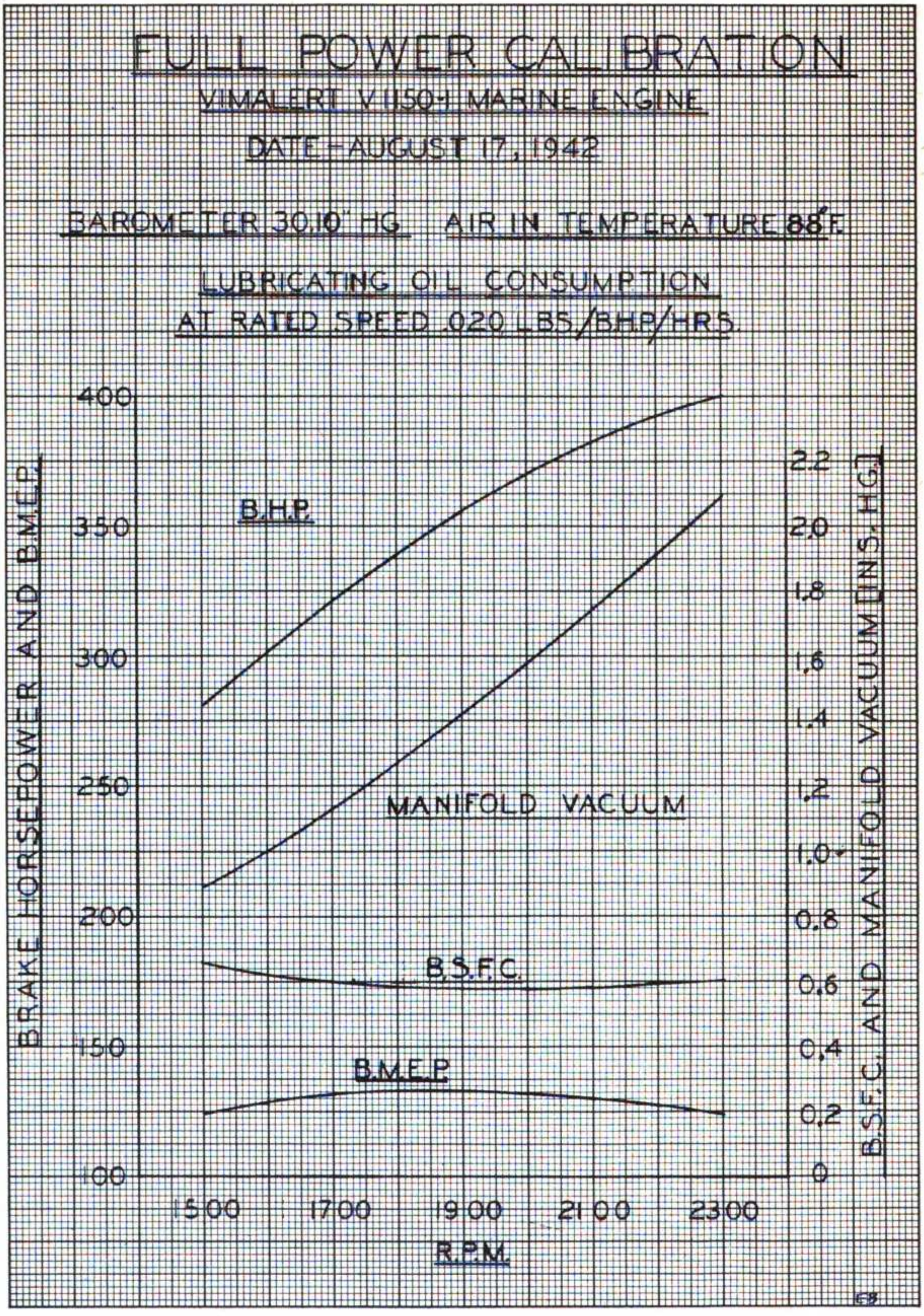
VIMALERT V1150-1 MARINE ENGINE

DATE - AUGUST 17, 1942

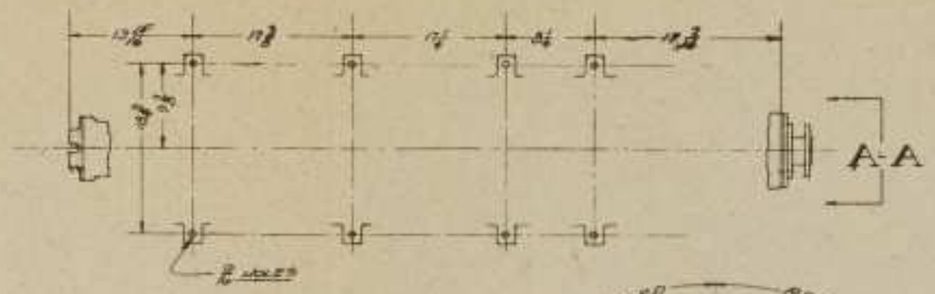
BAROMETER 30.10" HG. AIR IN TEMPERATURE 88°F.

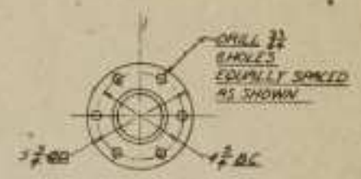
LUBRICATING OIL CONSUMPTION

AT RATED SPEED .020 LBS./B.H.P./HRS.

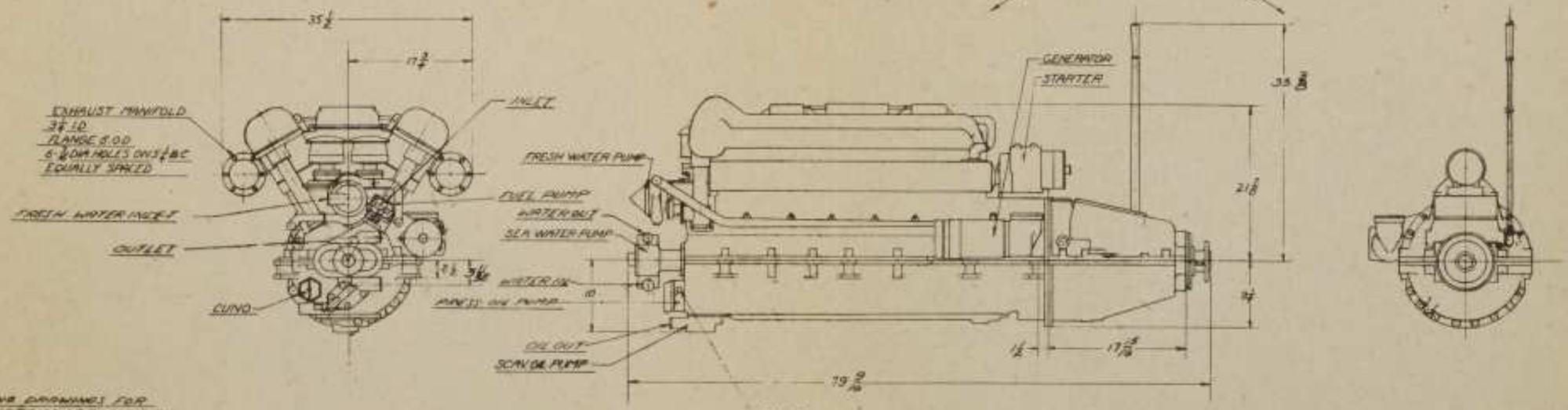


4-D



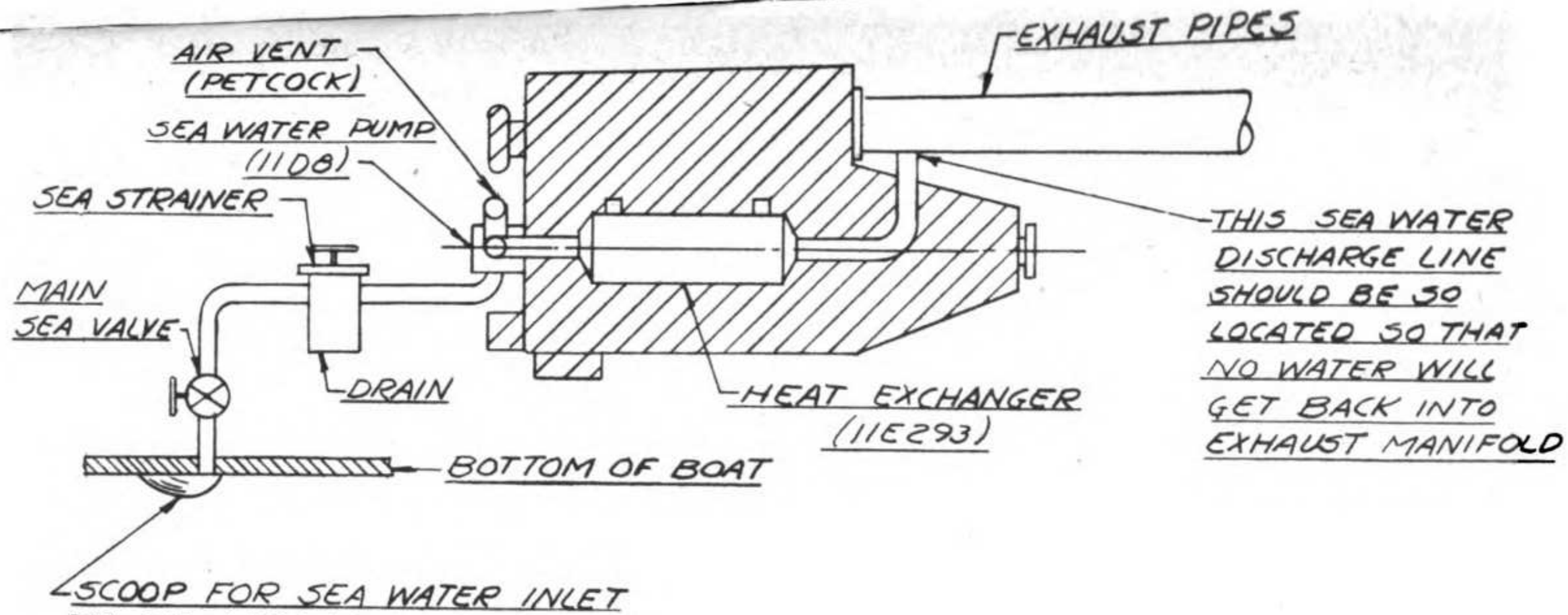


VIEW
A-A



SEE THE FOLLOWING DRAWINGS FOR INSTALLATION SYSTEMS OF THE BOAT.
LA 343 SEAWATER SYSTEM
LA 346 FRESH WATER SYSTEM
LA 347 OIL SYSTEM
LA 348 FUEL SYSTEM
ALL HOSE, PIPING, TUBE SIZES WILL BE FOUND ON THE DRAWINGS LISTED ABOVE.

INSTALLATION
ENGINE

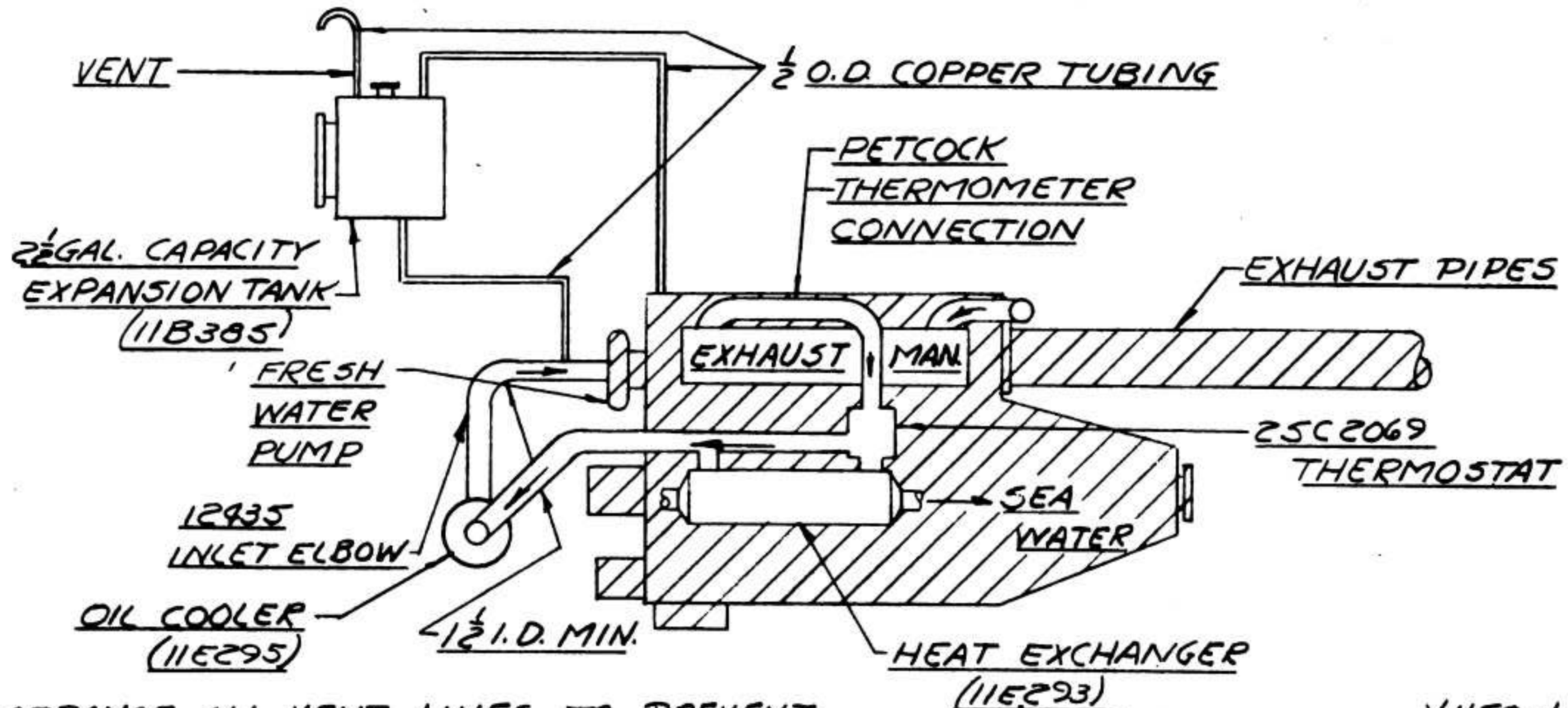


ALL LINES TO BE $1\frac{1}{2}$ PIPE OR $1\frac{3}{4}$ O.D. COPPER TUBING.

SUITABLE DRAINS MUST BE INSTALLED AT ALL LOW POINTS IN THE SYSTEM.

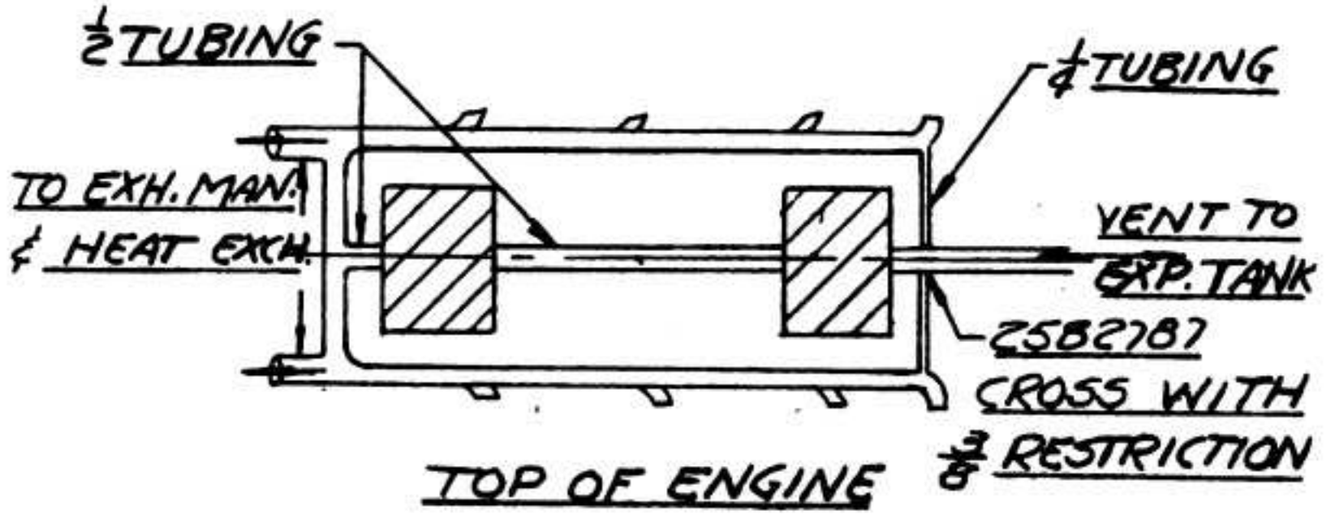
DOUBLE HOSE CLAMPS TO BE USED ON ALL PRESSURE LINES.

SEA WATER SYSTEM



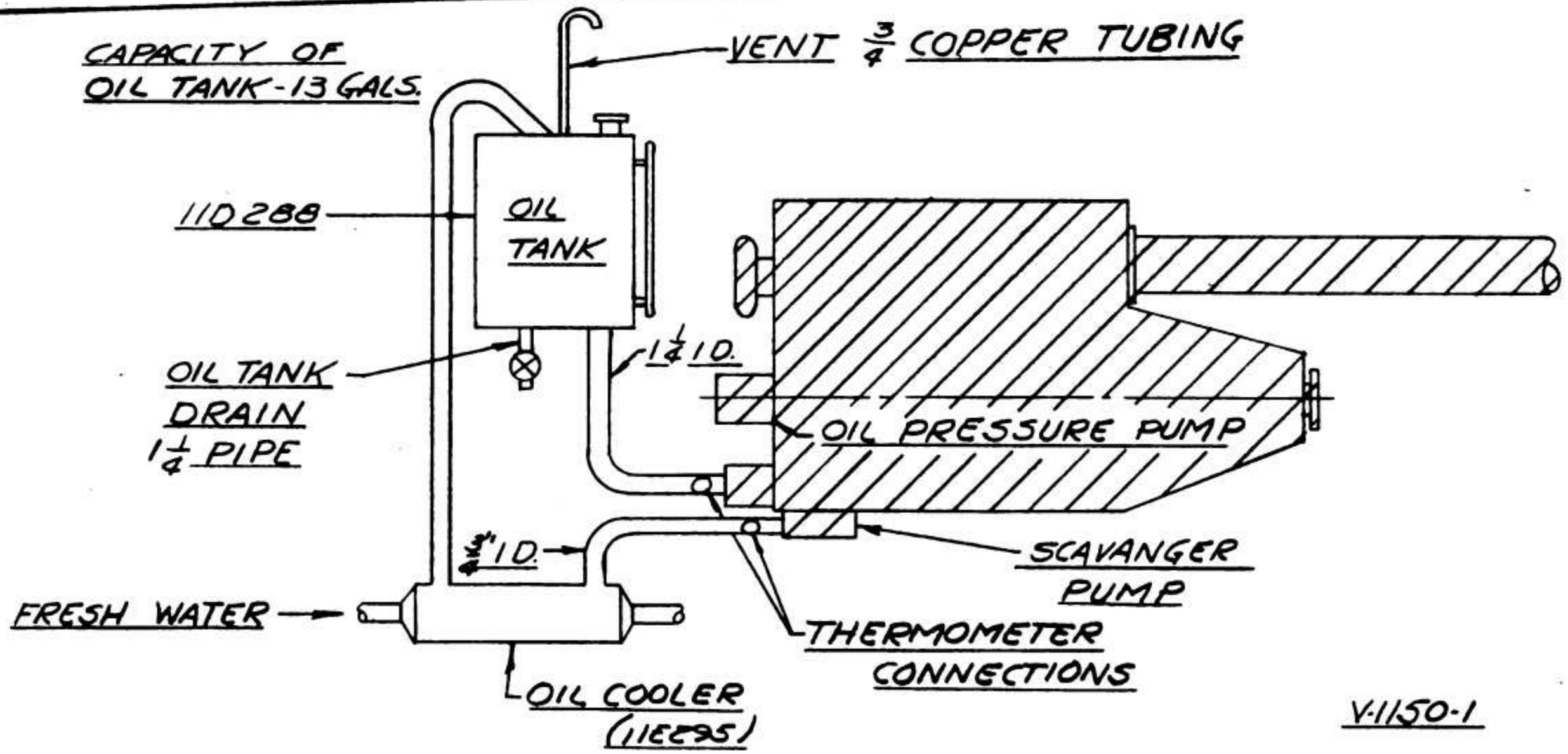
ARRANGE ALL VENT LINES TO PREVENT THE FORMATION OF TRAPS.

SUITABLE DRAINS MUST BE INSTALLED AT ALL LOW POINTS IN THE SYSTEM



V-1150-1

FRESH WATER SYSTEM



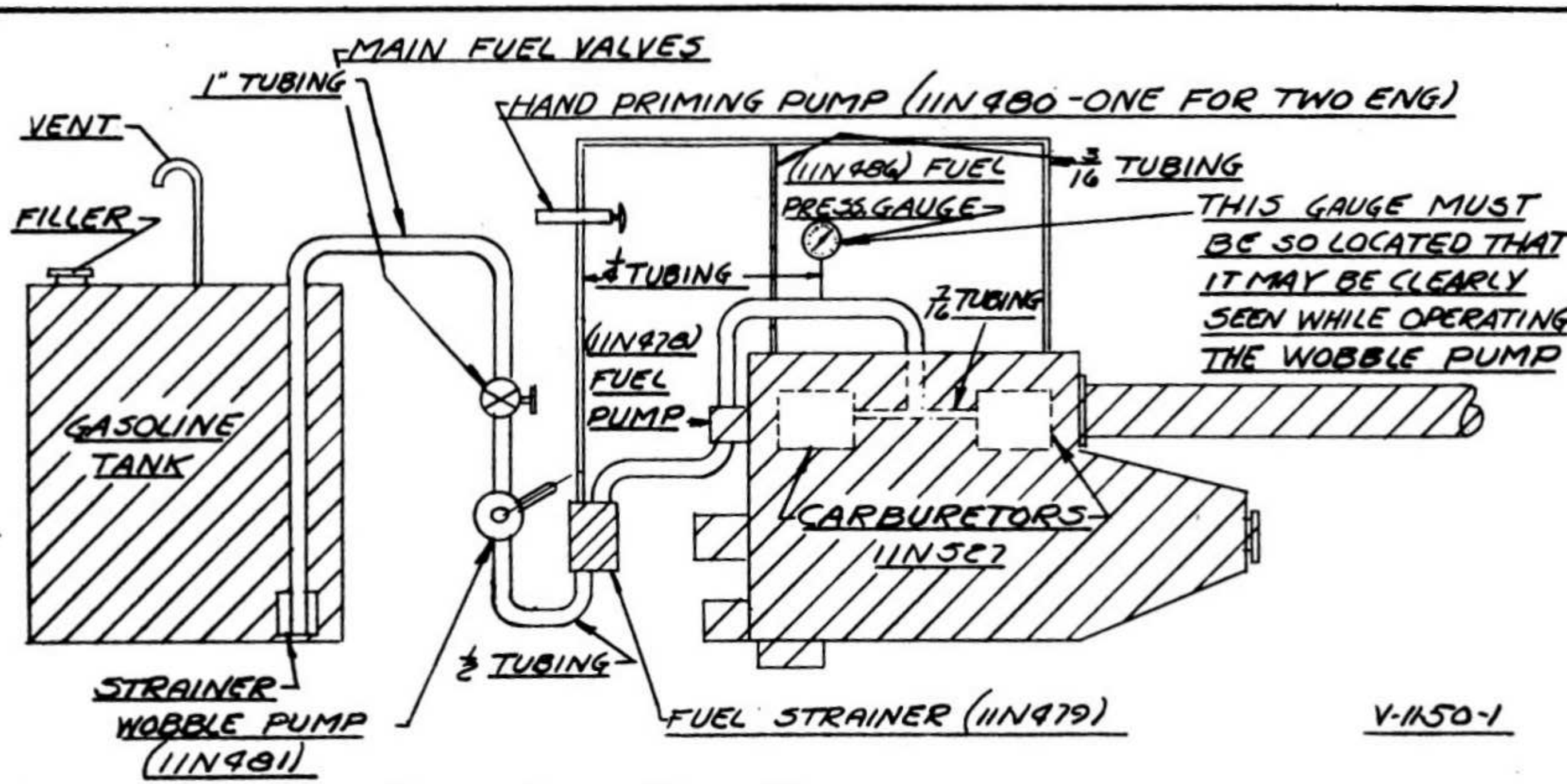
OIL PRESSURE GAUGE FITTING IS LOCATED ON RIGHT SIDE OF ENGINE LOWER CASE JUST AFT OF CUNO OIL FILTER

AT LEAST 10% CAPACITY OF THE OIL TANK SHOULD BE ALLOWED FOR EXPANSION OF OIL.

OIL TANK SHOULD NOT BE VENTED INSIDE BOAT.

ALL LINES MUST BE THOROUGHLY CLEANED OUT BEFORE INSTALLATION. DOUBLE HOSE CLAMPS TO BE USED ON ALL PRESSURE LINES.

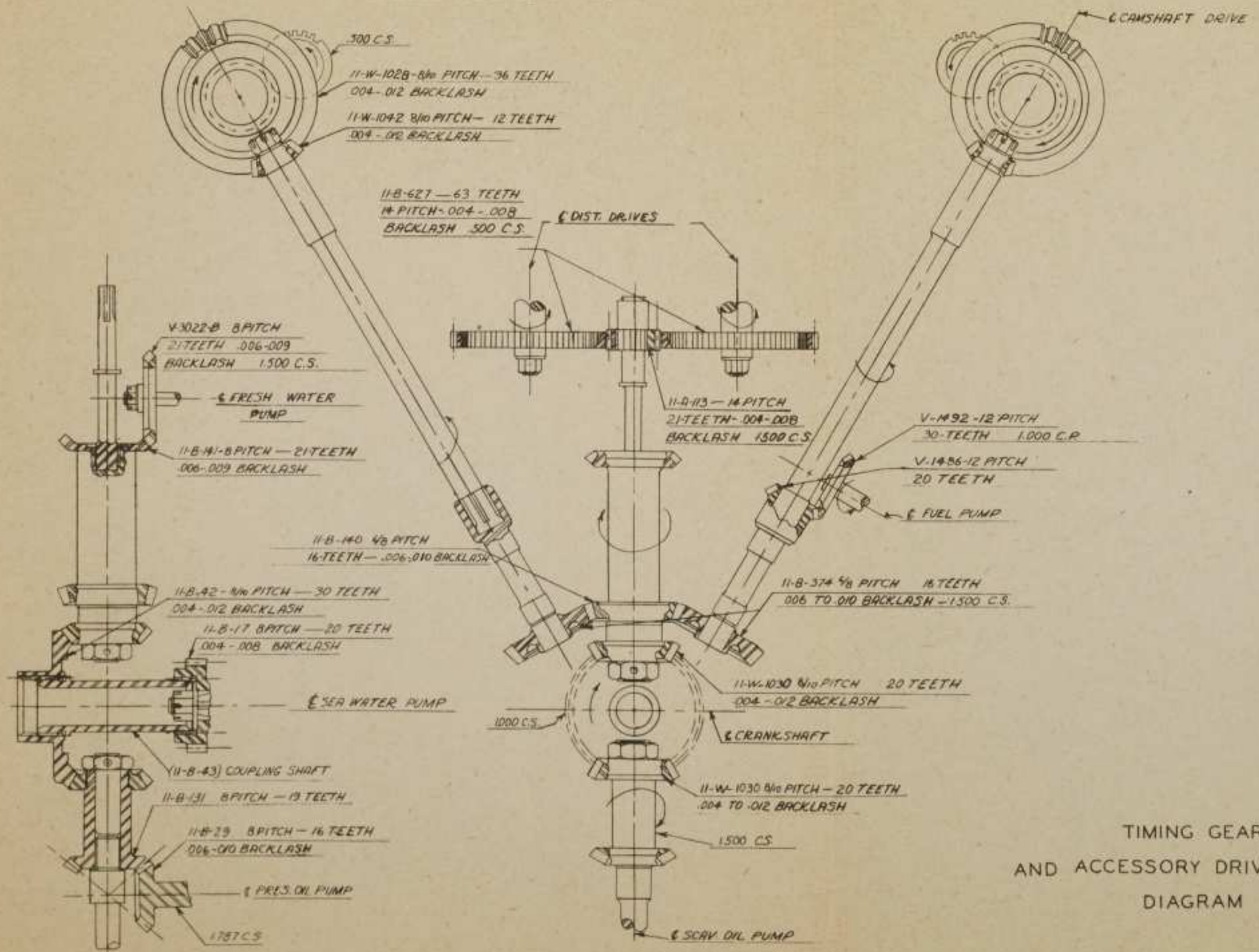
OIL SYSTEM



A SUITABLE DRAIN MUST BE PROVIDED AT THE LOWEST POINT OF THE AIR DUCT CONNECTING THE CARBURETORS.
IF PERMISSABLE FUEL SHOULD BE TAKEN FROM BOTTOM OF FUEL TANK OTHERWISE CONSIDERABLE CARE MUST BE TAKEN TO PREVENT AIR LEAKAGE INTO LINES LOCATED ABOVE THE LOWEST LEVEL OF FUEL IN THE TANK.

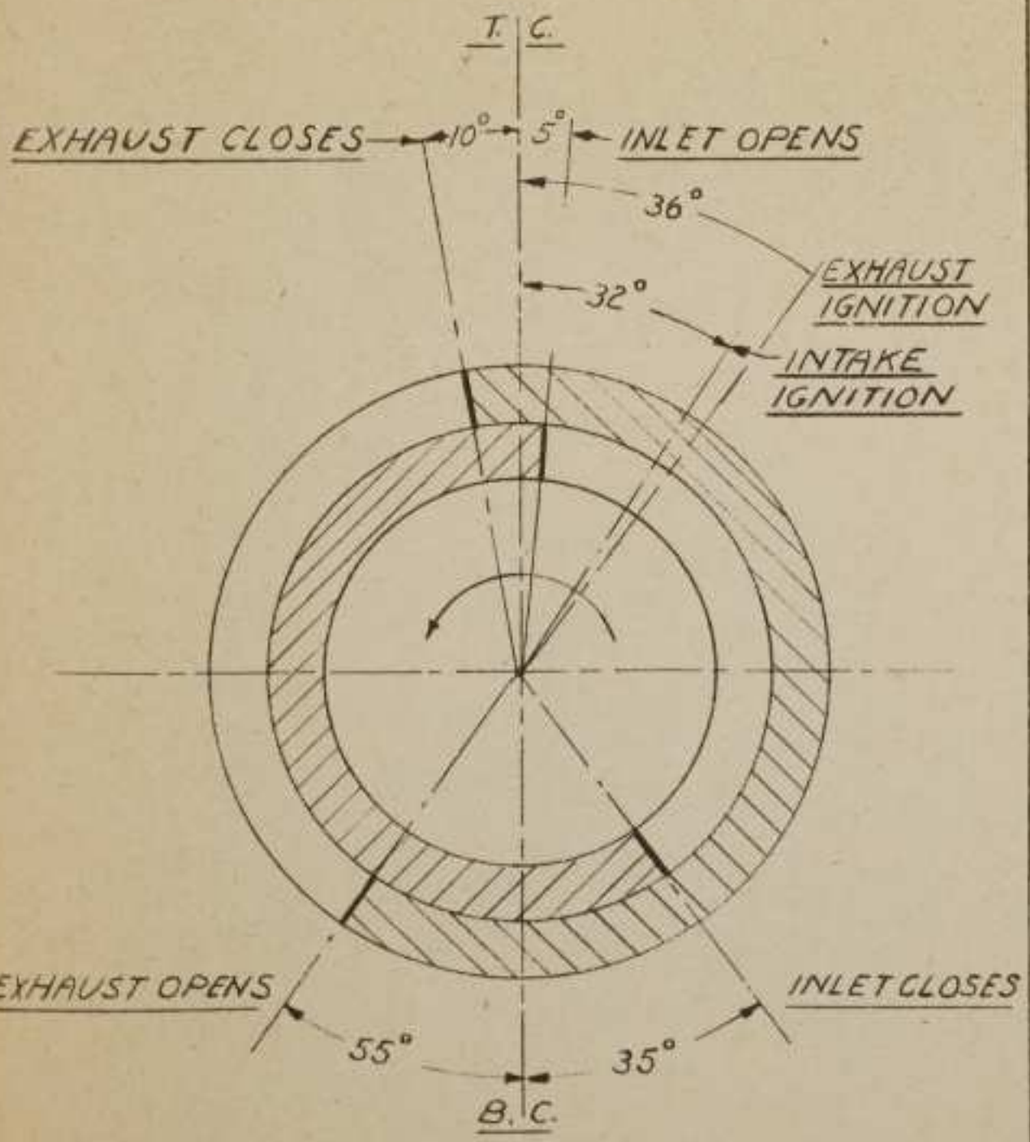
FUEL SYSTEM

NOTE:
GEARS NOT SHOWN-
(1)-11B-53 GEN. IDLER, 11B76 CRANKSHAFT GEN.
DRIVE & 11B-51 GEN. DRIVE - .010 - .014 BACKLASH
(2) 11-B-148 GEAR STARTING MOTOR PINION
& 11-C-136-GEAR BENDIX SHAFT - .006 TO .010 BACKLASH.



TIMING GEAR
AND ACCESSORY DRIVE GEAR
DIAGRAM

TIMING DIAGRAM

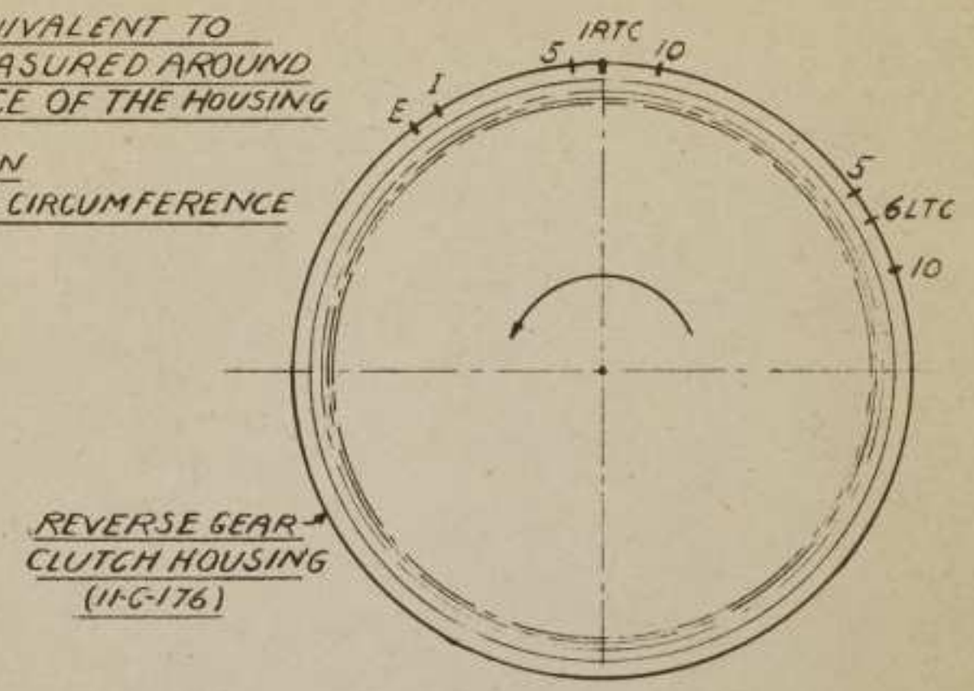


ALL ANGLES MAY VARY ±5° ON CRANKSHAFT

FLYWHEEL MARKINGS

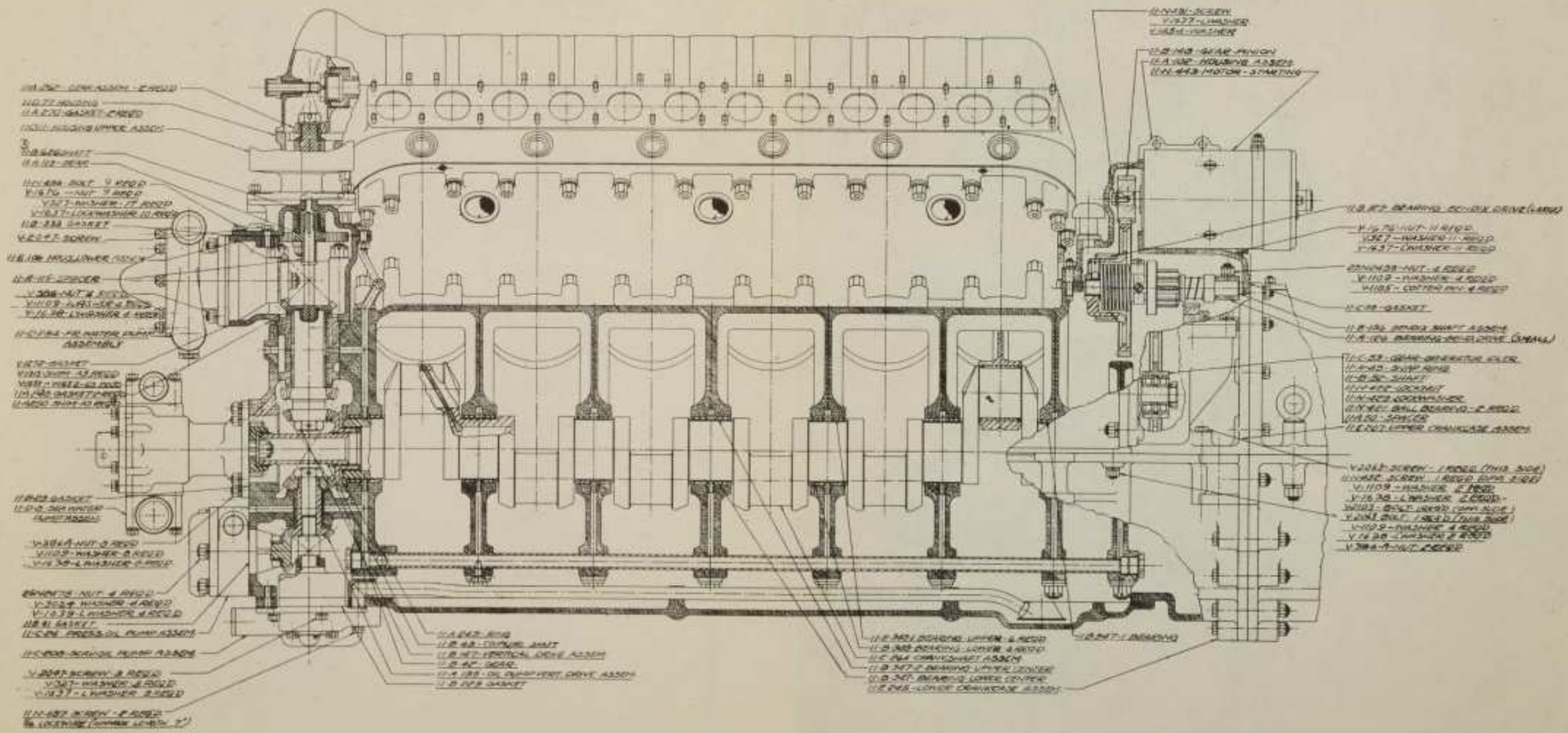
ONE DEGREE IS EQUIVALENT TO .11889 INCHES MEASURED AROUND THE CIRCUMFERENCE OF THE HOUSING

DEGREES	INCHES ON HOUSING CIRCUMFERENCE
5	.594
10	1.189
32	3.804
36	4.280



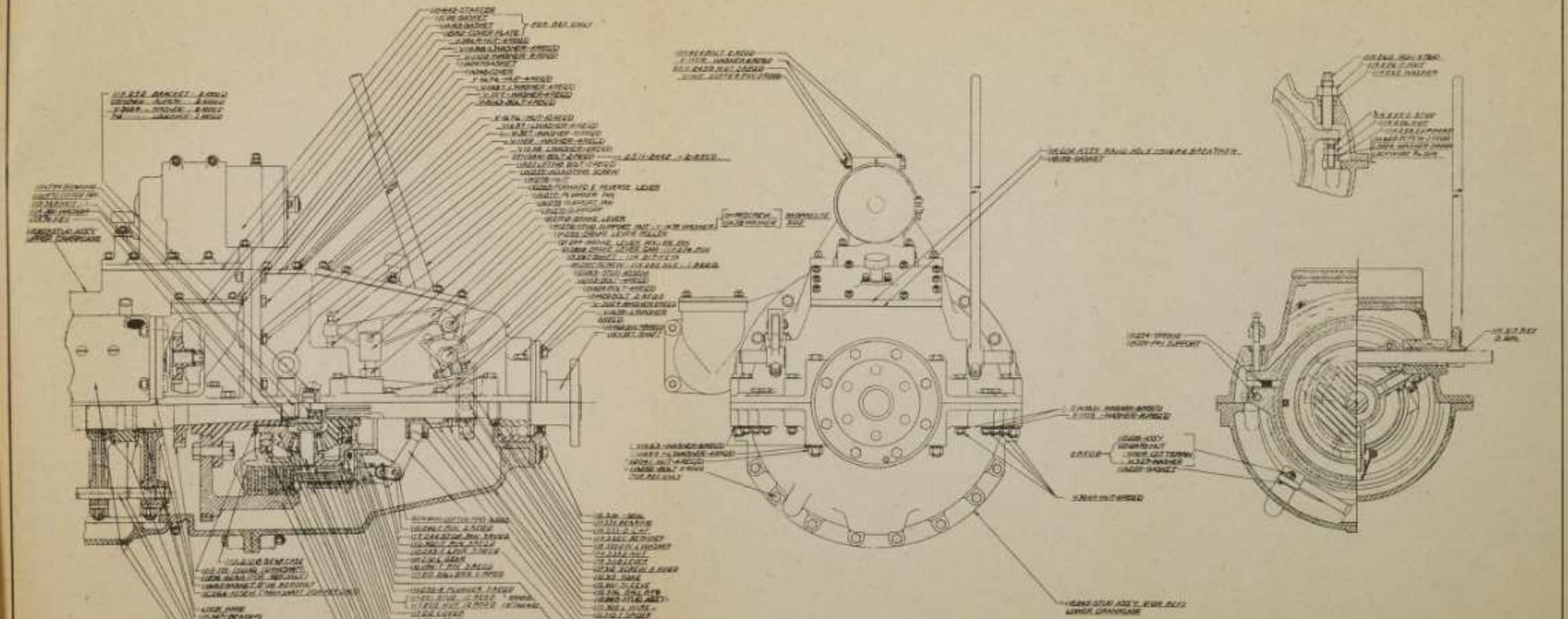
THE ABOVE MARKINGS ARE TO BE STAMPED ON THE CLUTCH HOUSING DURING INITIAL ASSEMBLY OF THE ENGINE DIRECTION OF ROTATION SHOWN – STANDING AFT OF ENGINE AND LOOKING FORWARD. IGNITION IS TIMED ON #1 CYLINDER OF THE RIGHT BANK. VALVES ARE SET ON "INLET OPENING" AND "EXHAUST CLOSING" AND ARE TIMED ON #6 CYLINDER OF THE RIGHT BANK AND #1 CYLINDER OF THE LEFT BANK.

TIMING & FLYWHEEL MARKINGS
OF THE V-1150 ENGINE



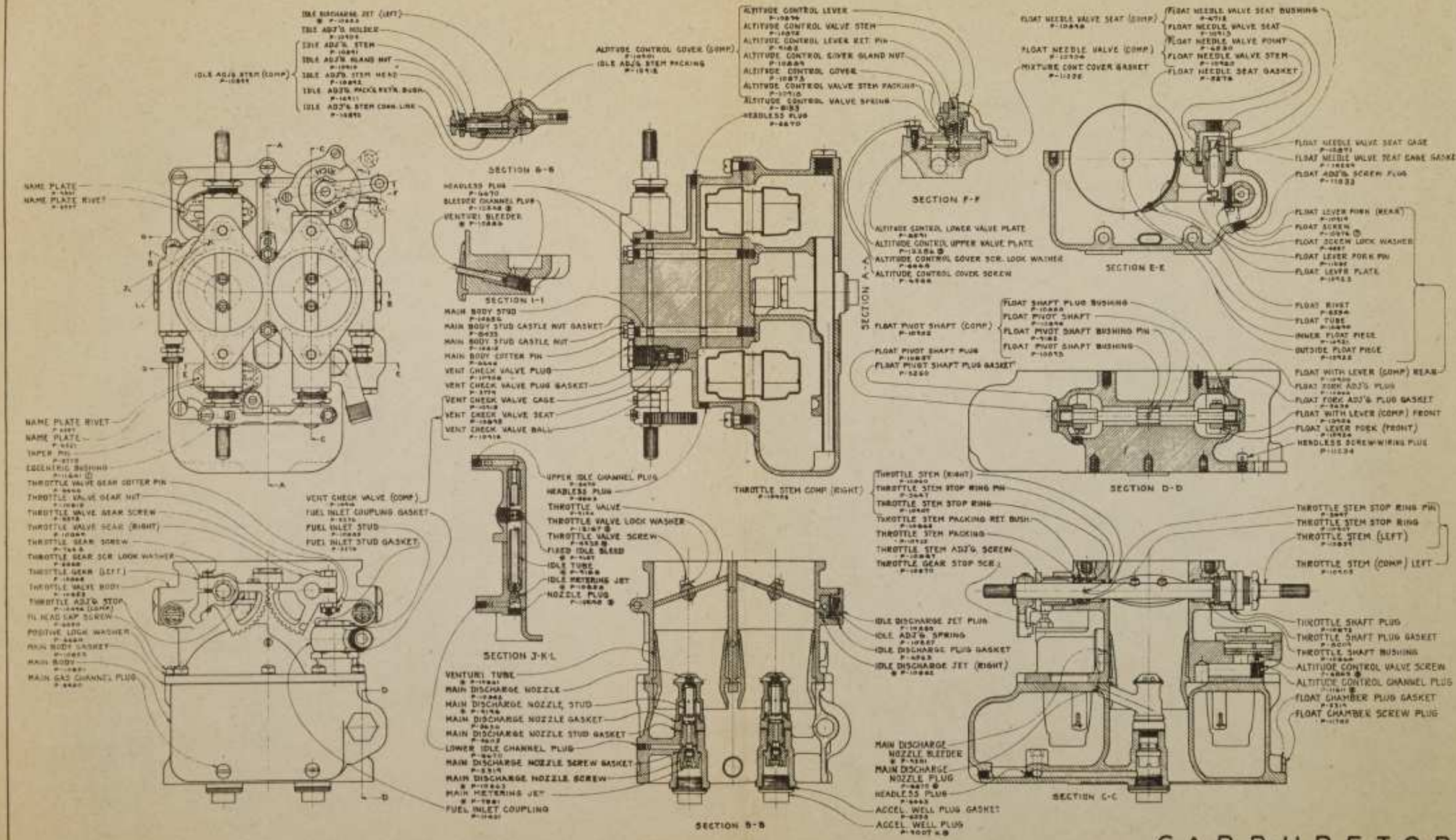
BASIC ENGINE

LONGITUDINAL SECTION



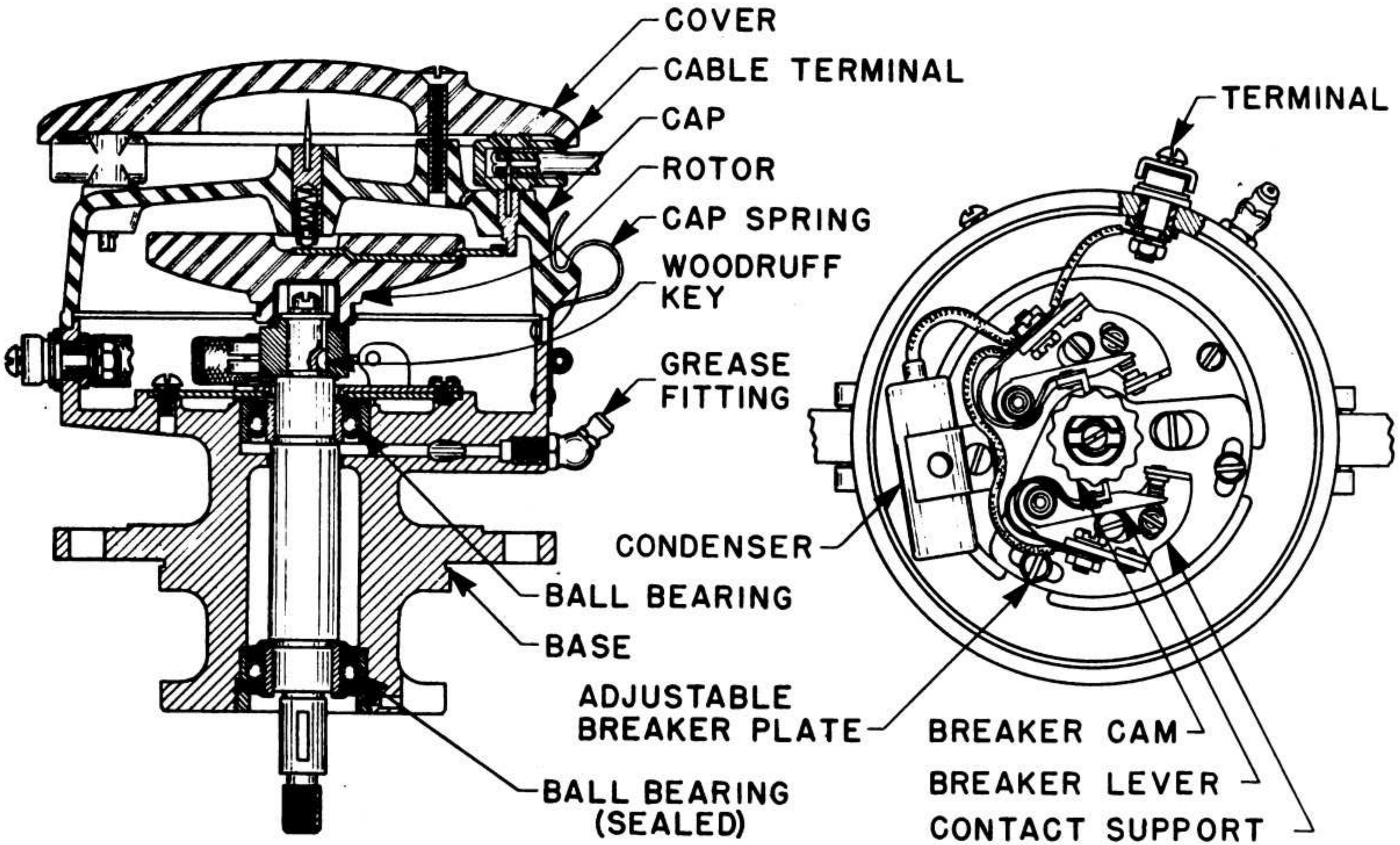
BASIC ENGINE

REVERSE GEAR ASSEMBLY



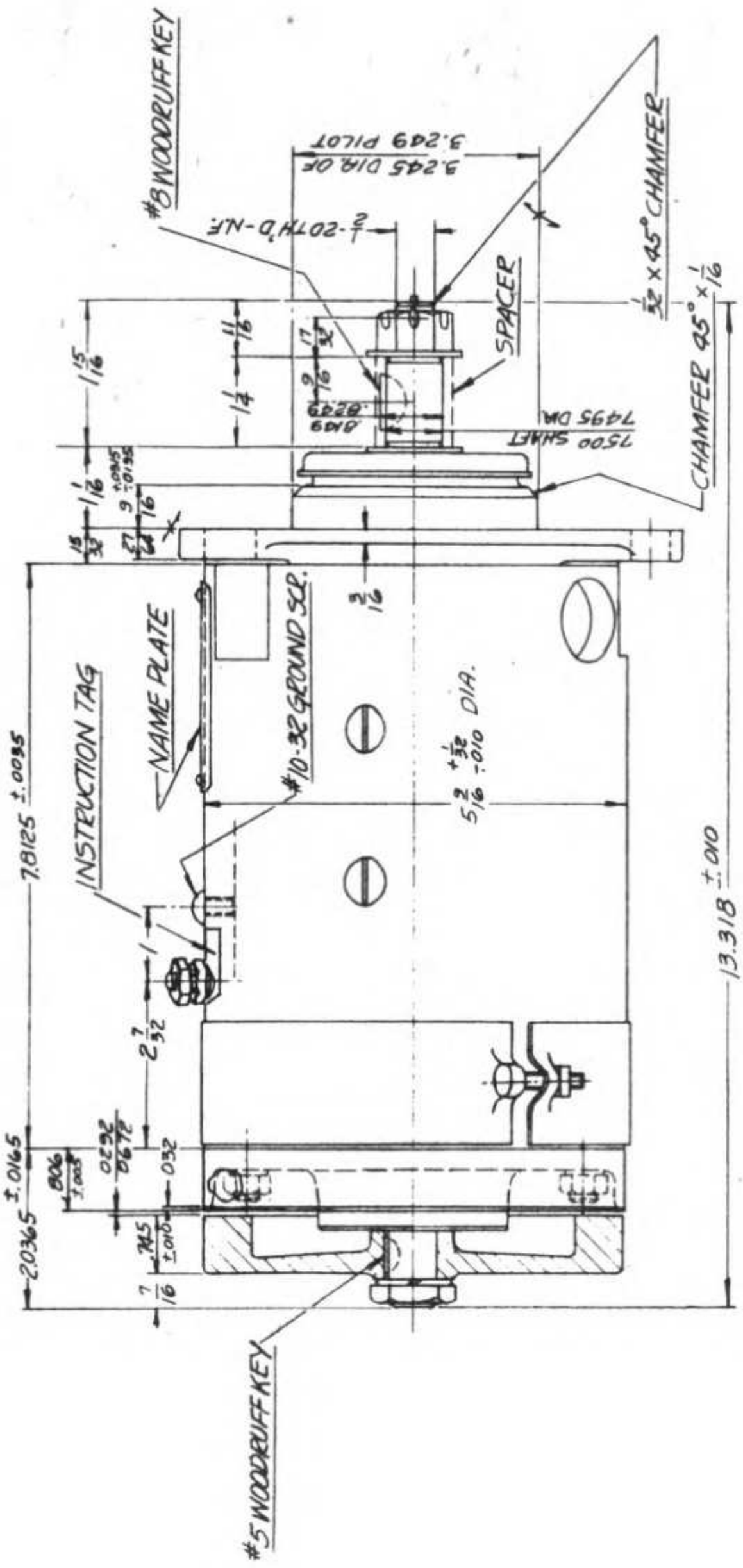
CARBURETOR

BENDIX STROMBERG CARBURETOR COMPANY



DISTRIBUTOR

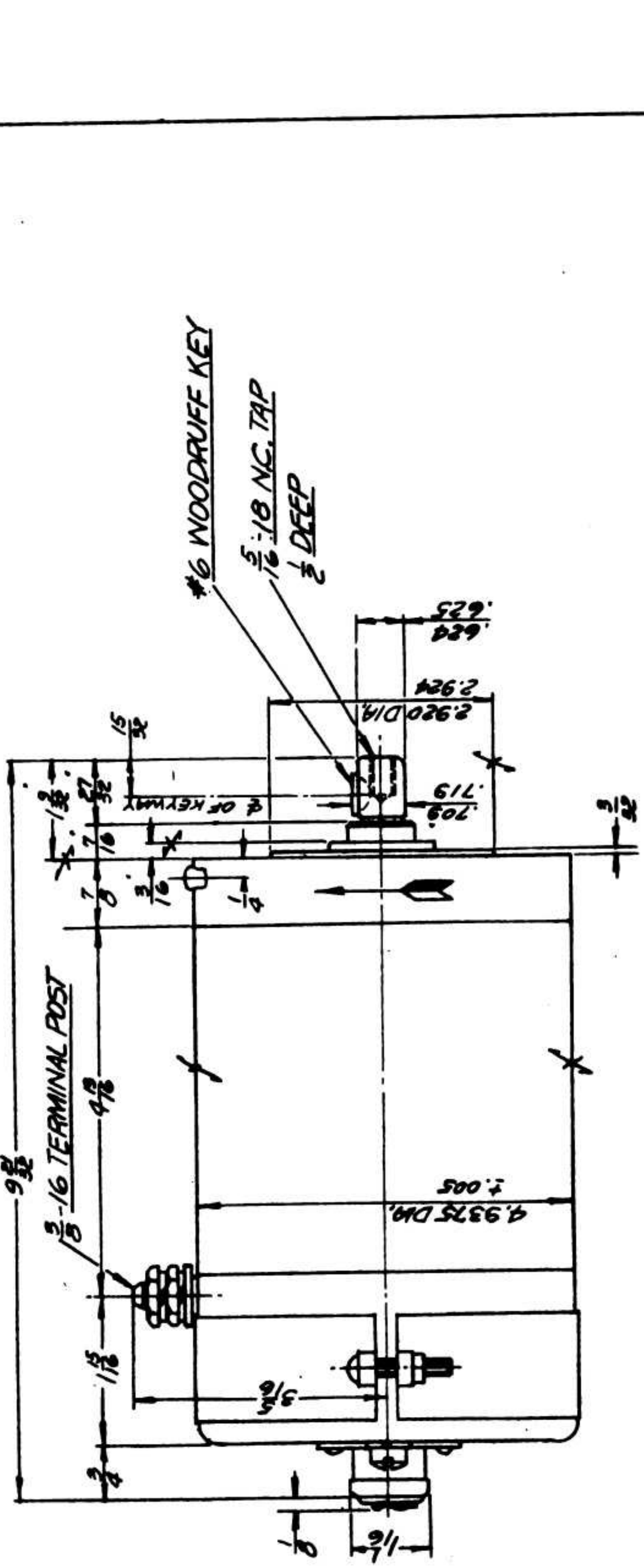
G E N E R A T O R

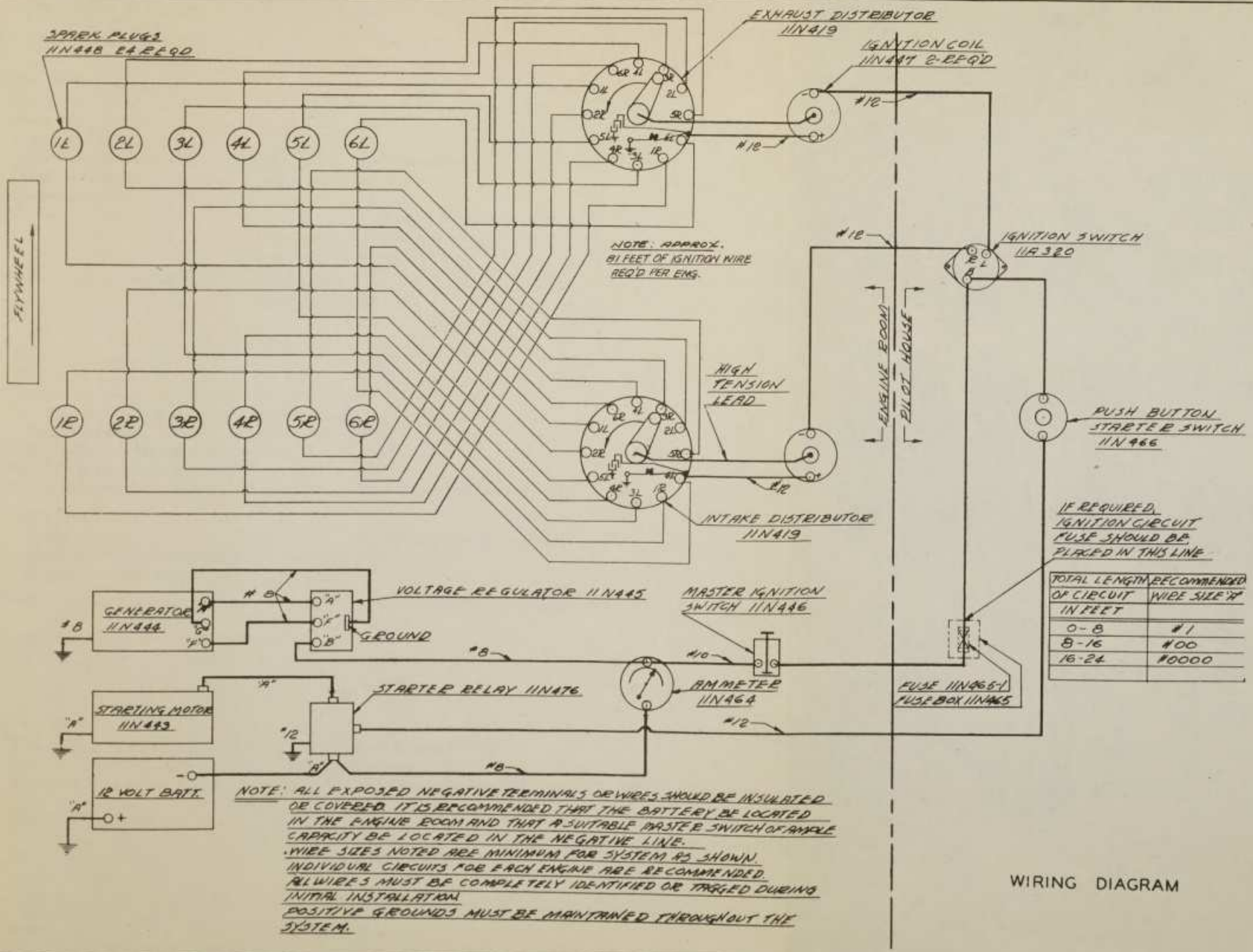


POLARIZE GENERATOR WITH POSITIVE SIDE GROUNDED.

4-Q

STARTER





WIRING DIAGRAM

GENERAL SPECIFICATIONS

Model V–1150–1

Rating ..... 400 H.P. at 2300 R.P.M.

General Form

- Bore ..... 4.5″
- Stroke ..... 6.0″
- Number of Cylinders 12
- Total Piston Displacement ..... 1145 cubic inches
- Cylinder arrangement ..... 60° Vee
- Compression Ratio ..... 5.3 to 1
- Cooling ..... Fresh water through engine. Sea water through heat exchanger to cool fresh water.
- Drive ..... Direct

Overall Dimensions and Position of Center of Gravity

- Length ..... 80″
- Width ..... 35½″
- Height ..... 31⅞″
- Height above engine bed ..... 24⅜″
- Depth below engine bed ..... 7½″
- Centerline of Crankshaft to engine bed ..... 2½″
- Distance center to center of engine bearers (Engine Hold Down Bolts) ..... 18¾″
- Minimum Distance between engine bearers ..... 16¾″
- Centerline of crankshaft to lowest point ..... 10″
- Height of Reverse Gear Lever ..... 32⅞″ above centerline of crankshaft

Center of Gravity

- Height ..... 4¾″ above crankshaft centerline
- Aft of centerline of forward engine hold-down bolts. 25½″
- Forward from rear face of driving flange ..... 41″

Weight ..... 1580 lbs. (including all components as shown on photograph)

Firing Order

Left Hand Engine

7	3	11	5	9	1	↓ Flywheel
2	10	6	12	4	8	

Ignition System

- Type ..... Dual, battery, 12 volt
- Coils ..... Delco-Remy, 12 volt
- Distributors ..... Delco-Remy, Rotation CW facing drive end of distributor
- Distributor Breaker Gap ..... .015″
- Spark Plugs ..... AC 83 or Champion 6 Commercial 62
- Spark Plug Gap ..... .020″
- Ignition Timing
  - Exhaust Plugs ..... 36° B.T.D.C.
  - Intake Plugs ..... 32° B.T.D.C.
- Switch ..... Dual Type
- Master Ignition Switch for Engine Room ..... Push-Pull

Valve Timing (plus or minus 5° on crankshaft) and Clearances

Intake Opens	5° B.T.D.C.
Intake Closes	35° A.B.D.C.
Exhaust Opens	55° B.B.D.C.
Exhaust Closes	10° A.T.D.C.
Intake Clearance	.015"
Exhaust Clearance	.015"

Fuel System

Carburetors ..... Two double barrel up-draft Bendix-Stromberg having the following setting:

NAY5D	
Barrel Diameter	2 3/16"
Venturi Diameter	1 3/4"
Main Metering Jet	#43 Drill
Main Air Bleed	#49 Drill
Upper Well Bore	7/32"
Upper Bleed Holes	4—#50 Drill
Lower Bleed Holes	8—#44 Drill
Pulsation Control Nozzle Bore	#29 Drill
Idle Feed Holes (two holes)	#52 Drill
Idle Metering Jet	#61 Drill
Idle Air Bleed	#47 Drill
Idle Discharge Jet	#48 Drill
Mixture Control Nozzle	#40 Drill
Mixture Control Valve Closes On	#60 Drill
Discharge Nozzle Holes	6—#26 Drill
Float Needle Seat	#9 Drill
Float Level (below parting surface)	1/8"

Fuel Recommended	72 Octane Minimum
Fuel Pump	Engine driven, rotary blade type with integrally built pressure relief and by-pass valve.
Fuel Pressure	3 to 5 lbs. per square inch (See Page 20)
Fuel Filter	Purolator Disc Type
Carburetor Priming Pump	Wobble Type—Hand-operated
Manifold Priming Pump	Plunger Type with single, dual or triple outlets depending on number of engines in boat.

Lubrication System

Type	Pressure
Oil Recommended	OE50 USA—Spec-2-104B (See Page 22 for grades, pressures, temperatures.)
Oil Pressure Pump	Gear Type
Oil Scavenger Pump	Gear Type
Oil Filters	Hand-turned, edge type filter
Oil Tank	Suggested Capacity approximately 13 gallons (Allow 10% of this volume for foaming space.)

Cooling System

Type	Fresh water using heat exchanger
Capacity per engine	11 gallons (as shown on photographs)

Fresh Water Pump

Type	Centrifugal
Capacity	100 gallons per minute

Sea Water Pump

Type	Gear, driven from forward end of crankshaft
Capacity	70 gallons per minute
Water Temperatures	Controlled by thermostats (See page 22.)
Anti-freeze Requirements	See page 21

Electrical System

Generator	12 Volt, D.C., Positive Ground—Auto Lite
Type	Shunt
Poles	2
Brushes	2
Rotation	Counterclockwise facing drive end
Speed	1.765 x engine speed
Control	Vibrating Type Current—Voltage Regulator
Generator Cut-in Speed	465 RPM engine speed
Lowest Engine Speed for full generator output	815 RPM
Voltage Regulator Assembly	12 Volt, D.C., Auto-Lite
Ground Polarity	Positive
Carbon Resistors	2 used—R1 marked 80, resistance 76 to 84 ohms R2 marked 20, resistance 19 to 21 ohms
Circuit Breaker	Contact point gap .015" minimum Contacts close 13.0 to 13.75 volts Contacts open 1.0 to 5.0 amperes discharge
Voltage Regulator Unit	Operating Voltage—Allowable Variation ±.30 volts. Temperature F 50° 60° 70° 80° 90° 100° 110° 120°. Volts 14.59 14.54 14.50 14.46 14.42 14.37 14.33 14.29
Current Regulator	Operating Amperage—29 to 31 amperes
Starter	Auto-Lite 12 volt D.C.
Rotation	Clockwise facing drive end of starter
Poles	4
Brushes	4
Starter Relay	Leece-Neville Electromagnetic Type
Starter Push Button	Leece-Neville
Battery	12 volts (1.240 suggested minimum gravity)
Generator Fuse and Fuse Block	40 Amps.
Ammeter	30–0–30 Amps.

Exhaust Manifolds

Type	Copper, entirely water-jacketed

Reverse Gear

Type	Bevel Gear, Planetary type
Lubrication	Force feed in forward, neutral and reverse
Reverse Speed	100% engine speed
Maximum engine speed in reverse	1500 RPM

Rotation of Propeller .....Left Hand (counterclockwise) standing aft and looking forward

Standard Equipment

1 Ammeter (30–0–30 Amps.)
1 Block-Fuse
1 Cable and Casing Assembly-Tachometer
22 Clamp-Hose—No. 3
22 Clamp-Hose—No. 5
2 Coil-Ignition
1 Cooler—Oil
1 Exchanger—Heat
1 Fuse (40 Amps.)
2 Gasket—Exhaust Manifold End Flange
1 Gauge—Fuel Pressure (0–10 P.S.I.)
1 Gauge—Oil Pressure (0–200 P.S.I.)
2 Gauge—Temperature (32°-212°F.)
1 Hose—1" I.D. x 2¼" long
5 Hose—1¼" I.D. x 2¼" long
3 Hose—1⅜" I.D. x 2¼" long
5 Hose—2" I.D. x 2¼" long
6 Hose—1¾" I.D. x 2" long
1 Indicator—Tachometer–0–2400 RPM
1 Panel—Instrument
1 Pump—Priming (Hand Type) with 2 Elbows
1 Pump—Wobble (Hand Type)
1 Push Button—Starter Switch
1 Regulator—Voltage
1 Relay—Starter
1 Strainer—Fuel
1 Switch—Ignition (Pilot House)
1 Switch—Ignition Engine (Engine Room Master Cut Out)
1 Tank—Fresh Water Expansion
1 Thermostat—Assembly
1 Wrench—Crankshaft Hub Nut (Per Two Engines)
1 Wrench—Spark Plug

STANDARD ENGINE CLEARANCES

Part	Min.	Desired	Max.	Allowable Before Replacement or Readjustment
Camfollower—dia. clear. in guide	.0005	.0015	.0025	.004
Camshaft—dia. clearance	.0015	.0020	.003	.005
Camshaft—end play	.005	.005	.015	—
Crankshaft—end play	.005	.005	.015	—
Crankshaft—dia. clear. in bearings	.002	—	.0045	.006
Connecting Rod on crank pin—dia. clearance	.0022	—	.0037	.006
Connecting Rod on crank pin—end play	.009	.009	.024	.040
Connecting Rod (link) on master connecting rod—end play	.006	.006	.008	.012
Gears (ALL) backlash when cold[1]				
Piston at top land	.017	.019	.021	.025
Piston at bottom of skirt	.010	.012	.014	.020
Piston pin in piston	.0005	.001	.0015	.003
Piston pin in connecting rod—dia. clearance	.0005	.0015	.002	.004
Piston ring at root of groove	.043	—	.077	—
Piston ring in groove	.001	.0015	.002	.005
Piston ring gap	.007	.008	.013	.020
Spark Plug Gap (B.G.)	.018	.020	.022	.035
Tappet Gap	.014	.015	.016	.018
Valve—dia. clear. in guide	.0025	.003	.004	.006
Link pin in master connecting rod—dia. clearance	.0001	—	.0003	—
Link pin in link connecting rod—dia. clearance	.001	.001	.0015	.006

STANDARD REVERSE GEAR CLEARANCES

Bell Crank ball end and insert	.001	.002	.003	.008
Bevel gear backlash when cold	.004	.008	.012	.020
Brake band and drum side clearance	.010	.012	.015	—
Reverse gear shaft in spider bearings	.010	—	.013	.020

[1]Refer to page 8.

End-wise location of link pin in master rod-end of link pin must not come closer than .005" to straight edge laid across side of big end.

TORQUES ON V–1150–1 ENGINE NUTS

Main Bearing Through Studs.....50 ft. lbs. Then tighten further to next cotter pin hole
Connecting Rod Bolts .....32 ft. lbs. Then tighten further to next cotter pin hole
Spark Plugs ..... 40 ft. lbs

DESCRIPTION

The following topics in this section are discussed to enable the operating personnel and mechanics to understand the design, construction, and functions of the Vimalert V–1150–1 Marine Engine.

Designation of Engine Ends

The following notation is used throughout this book:

1. The distributor end of the engine is to be designated as the front.
2. The flywheel, or reverse gear end of the engine, is to be designated as the rear.
3. A right hand engine is one which rotates clockwise when viewed from flywheel end.
4. A left hand engine is one which rotates counterclockwise when viewed from the flywheel end of the engine.
5. The right bank of cylinders is on the right side when viewed from the flywheel end of the engine.

6. The left bank of cylinders is on the left side of the engine when viewed from the flywheel end.
7. Cylinders are numbered starting from the flywheel end of the engine.

Crankcase

The crankcase is of cast aluminum alloy and is very rigidly constructed. Upper and lower portions split on the crankshaft centerline, and the respective parts of the eight main bearings are carried directly in the transverse webs of the crankcase upper and lower sections. The aluminum alloy reverse gear case is connected directly to the after end of the crankcase and houses the reverse gear proper and the large double row ball bearings that take the propeller shaft end thrust. The two sections of the crankcase are rigidly fastened together with through bolts.

Main bearings are steel back removable shells with babbit lining. The upper halves of the bearings are held in the transverse webs of the crankcase upper section by plain dowels; the lower halves are held in place in the transverse webs of the crankcase lower section by hollow oil tranfer tubes. Provision is made between the last two main bearings on the reverse gear end of the crankshaft to absorb any end thrust that this shaft might be subjected to due to angular installation of the engine in the boat.

At periods of overhaul, it is important that the crankcase be thoroughly inspected and that oil passages be thoroughly cleaned.

Crankshaft

The crankshaft is of the conventional eight (8) bearing type, made of chrome nickel steel. The shaft is machined all over and journals are accurately finished. Special plugs and transfer tubes are provided to convey pressure oil to the crankpins. These, as well as all other oil passages should be thoroughly cleaned out during each overhaul. The shaft itself should also be thoroughly inspected (including magnaflux) and cleaned at this period.

Connecting Rods and Bearings

The connecting rods are of the master and articulated type. Both rods are steel forgings machined all over. The lower end of the master rod is fitted with a babbit, steel back, renewable shell bearing. Link pin and piston pin bearings are of bronze. The link pin is held in its proper place in a boss on the master rod by a bolt and nut.

Pistons and Piston Pins

Pistons are high tensile strength aluminum alloy, and are fitted with two compression rings and one oil scraper ring, all of which are located above the piston pin. The full floating type, alloy steel piston pins are retained lengthwise in the piston by spring circlips, and are lubricated by spray from the crankpin bearings and by excess oil scraped from the cylinder walls by the oil scraper ring. This oil passes through small holes located just below the lower ring.

Cylinder Heads and Blocks

The cylinder sleeves are closed at the upper end, and are screwed and shrunk in the aluminum alloy cylinder head. The head is cast six en bloc. The sleeves are removable for replacement purposes only under the manufacturer's supervision. The aluminum alloy water jacket is cast in one piece and is assembled over the lower end of the six sleeves, the water joint being maintained between the sleeves and jacket by composition gaskets under the sleeve flanges. The upper joint is made tight with a copper asbestos gasket. The blocks are firmly attached to the crankcase by short studs at the crankcase decks.

Valves and Valve Gear

Each cylinder is fitted with four interchangeable steel tulip valves, two intake and two exhaust, seating directly in the steel cylinder sleeve head. The valve stem guides are cast iron. The camshafts are mounted on the top of the cylinder heads in six aluminum brackets, the shafts running directly in the aluminum. These brackets are carefully dowelled to the head and are interchangeable, no alignment, reaming, or hand scraping being necessary during manufacture or overhaul. The intake camshaft is driven by the exhaust shaft by means of spur gears at the distributor end of the engine. A bevel gear is mounted on the exhaust shaft as follows:

The spur gear on the exhaust shaft is extended beyond the width of the mating intake gear, and the bevel gear is internally splined to fit over this extension. A single large flanged nut holds this gear on the shaft. As the number of teeth on the spur gear differs from the number of teeth in the bevel gear, a very fine adjustment is obtained on the timing by shifting the gear in relation to the shaft.

One cam operates two valves through a Tee shaped camfollower working in a bushing in the cylinder head, the camfollower removing all side thrust from the valve stems. The valves are adjusted by adjusting screws clamped in the ends of the Tee camfollower. The camshaft bearings are pressure lubricated and the camfollowers and valve guides are lubricated by splash.

Accessory Drives (see page 8)

The camshafts, distributors, fresh water pump, sea water pump, pressure oil pump and scavenger oil pump are driven from the accessory drive shafts. This system is composed of a bevel gear splined to the end of the crankshaft which drives an upper and a lower vertical drive shaft, and the gears attached to these shafts from which the various accessories are driven. The camshaft driveshafts are parallel with the centerlines of the cylinders. At the upper end of the upper vertical drive shaft is located the spur gear which drives the two distributors.

The fresh water pump is driven from a bevel gear just below the distributor drive gear while the sea water pump is driven directly from the end of the crankshaft. Provision is made at this point to reverse the direction of all accessory drives on opposite rotation engines so that it is not necessary to maintain left and right hand parts for any of the accessories.

Located directly below the sea water pump is the oil pressure pump. This is driven by a bevel gear on the lower vertical drive shaft while the engine oil scavenger pump is driven directly from the end of this shaft.

The fuel pump is driven by a bevel gear located on the left camshaft drive shaft.

Flywheel Markings Used for Engine Timing (see facing page 8)

The following markings will be found stamped on the reverse gear clutch housing just under the timing inspection hole in the top of the upper reverse gear cover:

"1RTC," when in line with the inspection hole pointer, will indicate that the number one cylinder of the right bank is on top dead center. Thirty-six degrees before this mark is stamped an "E" and thirty-two degrees before it is stamped an "I". These marks are used to set the ignition timing of the exhaust and intake distributors respectively, for the right bank number one cylinder. To complete the timing, then, for the entire engine requires only the connection of the proper high tension distributor wires to the correct spark plugs in accordance with the firing order.

Five degrees before this "1RTC" mark is stamped a "5", and ten degrees after it is stamped a "10". These marks are used to set the valve timing (inlet opens five degrees before top center and exhaust closes ten degrees after top dead center) for the number six cylinder of the right bank. The number six cylinder is used for valve timing as the number six crankthrow is on top center at the same time as is the number one crankthrow. Therefore, number six cylinder is just starting the intake stroke while number one cylinder is just starting the firing stroke. The necessity of turning the flywheel through 360 degrees is therefore eliminated.

Approximately sixty degrees in a clockwise direction (standing aft and looking forward at the engine) from the "1RTC" mark is stamped a "6LTC" mark. This indicates that the number six cylinder of the left bank is on top dead center. As the number one cylinder of the left bank is also on top center when this "6LTC" mark lines up with the inspection hole pointer, it is obvious that it is only necessary to turn the flywheel in the direction of normal engine rotation from the "1RTC" mark to the "6LTC" mark (approximately sixty degrees) to set the valve timing for the number one cylinder of the left bank. The marks "5" and "10" either side of the mark "6LTC" are for this purpose.

Lubrication System (see page 6)

The lubrication system of the V–1150–1 engine is of the dry sump type. A gear type pump draws oil from an external oil tank and forces it under pressure to the main bearings, connecting rods, camshafts, camshaft bearings, accessory drive bearings and reverse gear. The oil is scavenged by an entirely separate scavenging pump which returns the oil through the oil cooler to the oil tank. The suctions of this scavenging pump are located in the forward and after ends of the oil pan and in the lower reverse gear case.

Located on the oil pressure pump is the pressure regulating or relief valve, which controls the pressure on the outlet side of the pump. This regulating valve is manually adjusted from the outside by releasing the locknut and turning the adjusting nut in the desired direction. Turning to the right (clockwise) increases the pressure; while turning to the left decreases it. The excess oil is by-passed to the suction side of the pump.

Located on the right side of the lower crankcase is a check valve which eliminates any oil flow from the oil tank into the engine during idle periods. Directly after this check valve on the oil pressure line is a disc type oil filter (Cuno). This filter should be kept clean, and in a free filtering condition at all times by turning the external handle. There is no danger of turning the handle too often or too much as there is nothing to wear out and nothing to replace. This handle may be turned while the engine is running.

A bronze tubular type oil cooler is supplied with each engine. The engine cooling water passes through the copper tubes, the oil passing through the spaces between them in a generally counterflow direction to that of the water.

An oil tank of approximately 13 gallons capacity should be used with each engine. The location of the tank filler should be such that it is impossible to fill the tank completely and therefore ample venting and expansion space (approximately 10 percent of total volume) is always provided at the top of the tank. During installation, the tank should be placed as near the inlet of the oil pressure pump as it is possible to get it so that short lines may be used throughout the system. Considerable care must be taken to keep the tank clean and free of foreign material both during installation and after the boat is in operation.

Fuel System (see page 7)

The fuel tanks and all piping up to the engine fuel pump are supplied and installed by the boat builder. This piping should accommodate the fuel strainer which is located at the low point in the line just before the pump. Special care should be taken to maintain a minimum number of valves and connections in these lines so that the possibility of any leakage is eliminated.

A manually operated wobble-type pump is installed so that the carburetors may be fully primed before the engine is started. During engine operation, an engine driven fuel pump maintains carburetor fuel pressure. This pump is driven from the left bank camshaft driveshaft at the forward end of the engine. An internal bypass compensates for all over-capacity of the fuel pump and maintains constant pressure on the carburetors.

Before installation on an engine, it is important that a new fuel pump be tested with oil by hand in order to determine if it is of correct rotation.

A plunger type engine primer is provided to inject fuel into the intake manifolds before cranking the engine. Suction for this hand primer must be taken from a point after the engine fuel strainer. Orifices are located in the primer fittings at the intake manifolds to distribute and atomize the fuel as it is injected into the manifolds. To use this primer, it is necessary to push the plunger in and turn it in order to release it from the locked position. Care must then be taken to return it to the "OFF" or locked position again after use.

Induction System

Two duplex updraft type carburetors are mounted on two divided intake manifolds. These manifolds are jacketed and warmed with fresh water. Each carburetor has two barrels of $2\frac{3}{16}$ inches actual diameter with throttle shafts running fore and aft, and geared together. The float mechanism is of the "Y" type with two floats in two chambers. The floats, however, are rigidly connected together and the float chambers are joined through a fuel passage so that the resulting action provides normal fuel flow to the jets even though the boat is pitching or rolling.

Air is delivered to the carburetors through an air cleaner screen attached to a duct which is located under the carburetors between the cylinder blocks.

Cooling System (see facing page 4 and page 5)

The engine is cooled by fresh water which is circulated by means of a centrifugal pump located just above the sea water pump on the forward end of the engine. This fresh water pump discharges into the distributing manifold at the lower part of each cylinder block water jacket. The water then passes upwards to the cylinder head, out through a manifold, and into the exhaust manifold jackets. Directly after the exhaust manifolds, the water passes through the thermostat, the fresh water heat exchanger, the oil cooler, and back into the inlet of the fresh water circulating pump.

A vent line is connected to the cooling jacket of the uppermost intake manifold and leads directly to the top of the fresh water expansion tank. Considerable care must be taken that these vent lines are so arranged that steam or air traps will not be formed in them and that all water passing through them will be completely drained when the engine stops. A line from the bottom of the expansion tank is connected to the inlet of the fresh water pump.

A gear type sea water pump is mounted on the forward end of the engine and is driven directly from the forward end of the crankshaft. Provision is made to reverse the position of this pump for opposite rotation engines so that the pump inlet and outlet are in the same relative position for both left hand and right hand engines. The pump driving gears are located inside of the engine crankcase and are lubricated with engine oil while the pump out-board bearings are water lubricated and require no attention. Shims, adjacent to the driving gear ball bearing outer races, are provided for adjusting the endwise location of the impellers in the pump bodies. If the shims should become misplaced during overhaul, the correct thickness is easily obtained by locating the impellers so that the outboard end surface (between the teeth and the outboard journal) of the gear hub is flush or .001 below the parting surface of the pump.

It is important that suitable drains be installed at all low points throughout the entire cooling system, for use in freezing weather when suitable anti-freeze has not been provided.

Ethylene Glycol (Prestone) and Water Anti-freeze Mixtures

% Volume of ethylene glycol	Baume reading	Specific gravity of solution at 60° F.	Freezing point of solution
10	2½°	1.016	26° F. above zero
20	4½°	1.031	16° F. above zero
30	6°	1.045	3° F. above zero
40	8°	1.058	11° F. below zero
50	9½°	1.070	31° F. below zero

Ignition System (see page 11)

Two complete and independent ignition systems comprised of two dual distributors and two coils are used for ignition on the engine, supplying the two spark plugs for each cylinder. The distributors containing the condensers, are mounted on the forward end of the engine and are driven at one-half crankshaft speed from the top of the vertical driveshaft. The left distributor fires the spark plug located on the exhaust side of each bank of cylinders, and the right distributor fires the spark plugs on the intake side of each bank of cylinders.

Distributors (see facing page 8)

The Delco-Remy ignition distributor uses the single spark principle. The breaker cam has twelve lobes with two sets of contact points, the breaker arms and contacts being arranged so that both sets of points open and close the coil primary circuit simultaneously or in synchronism.

The distributor shaft is supported on two ball bearings. Both bearings are the sealed type and require no additional lubrication. The spark advance is fixed and, therefore, on spark advance control is required.

The distributor cap has side outlets for the high tension leads and is openly constructed to prevent moisture from collecting between the leads. The leads are assembled in tight fitting rubber nipples, the leads being cut off squarely and assembled to the full depth of the nipples. When assembling the wire and nipple to the cap, the wire should be pierced by the needle point above each insert, and the flat surface of the nipple should fit squarely with the inside flat surface of the top part of the cap and insert. The needle points should be pressed through the nipple with a soft wood block to get the needle squarely through the wire.

The rotor is of the single spark principle. It is anchored to the circuit breaker cam by a semi-circular locking spring, which must be in place when the rotor is assembled onto the cam.

The points are adjusted as follows:

1. Adjust contact point opening of each set of points to .015 inch point opening or 21° cam angle (contact dowel).
2. Loosen the locking screws which hold the upper or movable breaker plate in place and rotate the eccentric screw to synchronize the two sets of contact points so they open and close simultaneously. Disconnecting the lead between the two contact supports, and connecting two test lamps to the contact sets, will provide a convenient means of checking synchronism. The two lights should come on and go out together as the distributor shaft is rotated. Breaker contacts should always make full, even contact with each other when they come together and should open the proper amount when fully separated.

Time the distributor to the engine in accordance with the instructions as specified, by loosening the hold down screws and rotating the distributor as necessary. If there is any occasion to loosen the cam, care must be taken subsequently to tighten the cam locking screw down firmly so that the cam will not loosen in operation.

Spark Plugs

AC 83 or Champion 6 Commercial 62 spark plugs are used on the V–1150–1 engine. In order to obtain satisfactory operation from these plugs the following suggestions are made in regard to their care and maintenance:

1. Always handle all spark plugs carefully. Never grasp in a vise, tighten abnormally, allow to get dirty, misuse, drop, or roughly handle any plug at any time.
2. Always wash each new plug with plain (not leaded) gasoline before installation in order to remove grease applied to them before they leave the factory. This same type of gasoline should also be used for cleaning used plugs and their terminals. Very fine sand paper not emery cloth, is used for polishing purposes.
3. The spark plug gasket should, if possible, be replaced each time a plug is installed.
4. Always use the proper torque to tighten the plugs in the engine. (See page 17.) More torque will usually result in plug distortion and change of the gap setting.
5. Care should be taken when installing plugs to be sure to use the proper wrench to grasp the plug by the hexagonal body near the lower end (the gap end) of the plug.

Generator and Starter (see pages 9 and 10)

The electrical system of the engine consists of the generator, the voltage regulator, the starter, the starter relay, the starter push button, the ammeter, the ignition switch and the required fuses.

At 12 volt, shunt type, D. C. generator is gear driven from the crankshaft and is mounted on the after end of the upper crankcase, where it is readily accessible. It is equipped with a reverse current cut-out and an electromagnetic voltage regulator which regulates the voltage within close limits. The generator furnishes power for ignition, keeps the battery fully charged, and furnishes additional power up to its capacity for other uses as may be required.

The voltage regulator is mounted in a metal box separate from the generator. During installation, the regulator should be placed near to the generator in order to eliminate as much wiring as possible.

The starter is mounted on the after end of the upper crankcase, and is arranged for remote push button control. The armature shaft carries a pinion gear which meshes with a larger gear on a countershaft. This countershaft carries the Bendix spring and pinion which meshes with the flywheel ring gear when the starter operates.

The starter relay is operated through the push button control on the instrument board energizing a solenoid in the switch box which closes the main contacts in the starter circuit. This relay should be mounted as close as possible to the engine so as to shorten the wiring. The following table should be used as a basis for the wiring system connecting the battery, starter, and relay:

Total length of circuit in feet...	0–8	8–16	16–24
Recommended Wire Size.....	#1	#00	#0000

(See Wiring Diagram, page 11.)

It is important to check all wiring connections including those on the generator, regulator, starter, ammeter, starter relay, battery and ground to be sure that they are clean and tight. Special attention should be given to the battery connections as these are subject to corrosion and must be protected.

Reverse Gear

The reverse gear is of the bevel gear, planetary type operating in conjunction with a multiple disc clutch to give the forward, neutral and reverse conditions. (See Reverse Gear Assembly, facing page (8). The mechanism is operated manually by means of a lever located on the side of the reverse gear housing.

In the forward position, the entire assembly of the flywheel, clutch, pinion cage, and pinions turns as a unit. The toggle joints located around the clutch throw-out bearing collar are in the over center position and hold the clutch plates tight, allowing the driving torque of the engine to be transmitted to the engine hub shaft.

In the neutral position, the toggle joints release the pressure on the clutch plates, and, as the brake bands have not yet tightened on the brake drum, the reverse gear shaft is free to run independent of the motion of the crankshaft. This results in a planetary action being set up, causing the gear cage and pinions to rotate slowly around the now independent reverse gear shaft gear.

In reverse, the brake bands are tight on the brake drum while the plate clutch is still released. This fixes the position of the pinion cage and the pinions, and results in a counter-rotation of the reverse gear shaft. (See illustration facing page 8.)

The reverse gear shaft is located endwise by a large duplex ball bearing which takes all propeller thrust both in forward and reverse.

OPERATING INSTRUCTIONS

Recommended Operating Pressures, Temperatures and Speeds

(Pressures are in pounds per square inch.
Temperatures are in degrees F.)

Oil pressure:

Desired	90 at 2300 R.P.M.
Maximum	100 at 2300 R.P.M.
Minimum	85 at 2300 R.P.M.
Idling	20 minimum

Fuel pressure at carburetor desired.....3 to 5

Oil in temperature under way:

Grade	OE 50, USA—Spec–2–104B
Desired	120
Safe maximum	145
Safe minimum	100

Oil out temperature:

Safe maximum	220

Fresh water temperature out of exhaust manifolds:

Desired	160
Maximum	180
Minimum	140

Maximum forward speed	2300 R.P.M.
Minimum forward speed	600 R.P.M.
Maximum idling speed	800 R.P.M.
Desired idling speed	600 R.P.M.
Maximum reverse speed	1500 R.P.M.
Desired engine speed for shifting reverse gear	800 R.P.M.

Preparation for Operation

1. Read this handbook carefully.

2. Maintain a log of engine operation.

3. The operator should be thoroughly familiar with the piping and electrical systems so that the proper valves and switches will be open or closed, as the case may be, for proper engine operation.

4. The engine should be handled strictly in accordance with instructions at all times.

5. Make a final inspection of the boat to make sure that no explosion or fire hazards are present.

6. Check all instruments and gauges.

7. All strainers and filters of the fuel, lubricating oil and water systems should be inspected and cleaned, if necessary. Clean oil filter after first two hours operation of a new engine or after a new installation.

8. Make sure that the carburetor throttles open and close fully.

9. Fill the engine oil supply tank approximately ¾ full (do not fill to capacity) with OE 50, USA—Spec–2–104B. (See page 22.)

10. See that all drain plugs are in place, that all required petcocks are closed, and all vents are open.

11. See that there is sufficient fuel in the tanks. (72 octane minimum).

12. Check the condition of the storage batteries. (Level, specific gravity, and cleanliness).

13. Fill the fresh water cooling system.

14. Turn the engine over by hand through four complete revolutions to make sure that there are no liquids or other obstructions in any of the cylinders. If the engine has stood idle for more than one week, it is advisable to inject approximately one teaspoonful of lubricating oil through a spark plug hole in each cylinder.

Starting Instructions

1. Make sure that all valves on the oil inlet line from the oil tank to the oil pump are open. These valves should be used only in an emergency and during all normal operation of the engines they should be securely locked with wire in the open position. Provision has been made in the engine crankcase to prevent oil seeping from the oil tank into the engine during idle periods.

2. Open all sea cocks and close all drains.

3. Be sure that the engine cooling system has been properly vented and filled.

4. Open fuel supply valves.

5. Fill the carburetor bowels by using the Type D–2 Wobble pump until a pressure of 3 to 5 pounds per square inch is maintained in the carburetor inlet line. Check the carburetor air scoop drains for gasoline leakage. If leakage occurs, it indicates that the needle valves in the carburetors are not properly closing. This should be investigated and corrected before proceeding further.

6. Prime the engine before starting by using the small plunger pump provided for the purpose. About four strokes of the plunger are sufficient to start a cold engine. If the engine is hot, do not use the priming pump. After priming, be sure to leave the primer in the off or locked position. (*Note*: To operate primer, push the handle all the way down and turn to "on" position.)

7. Move the throttle control lever almost to the closed position. It is important to always keep one's hand on the throttle when starting the engines so that proper engine speed may be obtained immediately after the engine starts. (See page 22.)

8. Make sure that the reverse gear is in the neutral position.

9. Turn on ignition switch and press the starter button. If the engine does not start immediately, it is important that the starter button is not held down for prolonged periods. Use it at intervals. Allow the starter to come to a complete stop before attempting another start.

10. The oil pressure gauge should be observed immediately to make certain that oil is being furnished to the engine. If there is no pressure after engine runs for 15 seconds, the engine should be stopped immediately and the trouble located and remedied.

11. Allow the engine to warm up thoroughly at moderate speed until the fresh water "out" and "oil-in" temperatures have reached proper values. (See page 22.) During this warming-up period, make sure that the fresh water circulation system is functioning properly, and that all air has been eliminated from the cooling system.

12. If possible, it is better to warm up the engines under way as there will be less danger of fouling spark plugs. Do not idle in neutral any longer than is absolutely necessary.

Forward Operation

1. Close throttle to obtain desired engine speed for manipulating the reverse gear.

2. Place the reverse gear in the forward position.

3. Do not increase engine speed above 1000 R.P.M. until proper operating temperatures are obtained. (See page 22.)

4. Check pressures and temperatures every few minutes during preliminary running. In the event of sudden changes in pressures or temperatures, or abnormal changes outside the allowable limits, stop the engine immediately, investigate, and correct the cause.

5. Make sure that the engine is firing properly in all cylinders. Uneven firing cannot usually be detected in the engine room, but can more readily be detected by listening to the exhaust. Turning off the ignition from one set of plugs at a time will facilitate determining if the engine is firing properly.

6. Check for leakage regularly in external fuel, oil, sea water, and fresh water lines. If leaks are discovered, correct same as soon as possible.

7. Turn lubricating oil Cuno strainer several revolutions hourly while running engines.

Stopping Instructions

1. Operate the engine at slow speeds for several minutes to allow it to cool down before turning off the switches.

2. Turn off the ignition switch simultaneously with the complete closing of the carburetor throttles.

3. Close the fuel supply valves.

Operating Precautions

1. Do not race engine.

2. Do not run ahead or astern with either the clutch or the reverse gear brake bands slipping. An indication of clutch or band slippage is an increase of engine speed or intermittent engine accelerations without changing the throttle position.

3. Close the throttle in order to operate the reverse gear.

4. Make sure that there is always an ample supply of oil in the oil tank. It is recommended that at least one service tank full of oil be maintained in the auxiliary oil tank at all times.

5. Do not overload engines. "Pinging" is an indication of overload.

6. Whenever during periods of inactivity there is a possibility of the engine room temperature falling to freezing, drain all cooling systems completely unless proper protection is afforded by suitable anti-freeze.

7. Maintain engine-propeller coupling alignment.

8. Keep all engine controls and linkages lubricated and operating freely.

9. Maintain inspection routine.

SERVICE INSPECTION AND MAINTENANCE

General Scope of Work

The work outlined in this section is a normal function of the operating personnel. It consists of periodic inspection, cleaning, servicing, lubrication, adjusting, and such maintenance work as the organization facilities will permit.

The inspection and service requirements given herein are to be considered the minimum requirements.

Personnel, in performing this operation, should enter upon the Service Inspection Record the date of inspection, what defects were found, and what was done towards their correction and elimination.

It is important to note, at this point, that should it be necessary to order parts for the engine at any time, it is best to order them by name as well as number.

First Run Inspection

The first run inspection is a check of the engine prior to the first run of the day. Prior to the first run each day, each engine shall be given a first run inspection.

Fuel and oil quantities must be checked each day the engine is to be run, prior to the first run of the day. Checks made on a previous day, whether the engine has been run or not, must not be considered part of this First Run Inspection.

Fill fuel tanks with 72 octane (minimum) rating gasoline.

Fill oil tank with OE 50, USA–Spec–2–104B lubricating oil. (See page 22.)

Enter the quantities of fuel and oil added on the Engine Report.

Add water to fresh water expansion tank if necessary or fill cooling system if it has been drained. Allow adequate time for system to fill and all air to vent before checking water level.

If anti-freeze solution is required, check the solution to see that the desired protection against freezing is provided. (See page 21.)

See that all tank caps are properly secured.

When practicable, before starting engine the first time each day, and in all cases where the engine has

not been warmed up within the past seven days, turn the engine by hand at least four complete revolutions with cranking bar before using the starter. One teaspoonful of light lubricating oil should be put in each cylinder through spark plug hole if engine has not been used for more than one week.

Prior to starting the engine, check all instruments for proper pointer position, broken or loose, cover glass or other visible defects. Clean all instrument cover glasses with a clean cloth. Scratches, fingerprints, etc., disturb the lighting and make readings difficult. Inspect instrument lighting system and replace any defective lamps. During engine warm up check for proper functioning.

The battery should be fully charged. Check with hydrometer. 1.240 minimum gravity is required. Check the water level in all battery cells and fill with distilled water if necessary.

Daily Inspection

If practicable, the regular daily inspection should be accomplished during a period definitely set aside for that purpose, either after the day's running is over or before the start of running the following day.

Any marked deviation in oil temperatures or pressure or water temperatures from those set forth in the Table of Recommended Operating Pressures, Temperatures and Speeds should be investigated and corrected as soon as observed. Such items should not be left until later inspection periods for adjustment.

Fuel System.—Inspect for proper functioning and general condition of the carburetor throttle control assemblies from the levers in the pilot house through all rods, their linkage, supporting brackets, guides, pulleys, etc. Lubricate all controls so that they are free throughout their operating range. See that the linkage is properly adjusted, and that no bolts, nuts, screws, or cotter pins are missing or loose.

Inspect for fuel leaks after filling all fuel tanks. Particular care must be taken concerning all fuel lines situated above the level of the fuel in the tanks and on the suction side of the engine-driven fuel pump. Leaks in these lines will allow air to enter them, possibly resulting in erratic engine operation, backfiring, and stalling. All fuel valve packings must be kept tight.

Drain the fuel filter.

Carburetors.—These carburetors are of the plain tube type, and there are no moving parts to wear. Once set for the engine, they should function properly at all times, unless there is some actual part breakage, stoppage of fuel or similar failure.

The range of idle adjustment on these carburetors is effective only from extreme idle to approximately 600 or 700 R.P.M. of the engine.

The regulation is actually done by turning the idle adjustment screw. Turning clockwise or inward makes the mixture leaner, while a counterclockwise motion richens the mixture. There is a slight amount of lost motion in this mechanism which cannot be eliminated. The adjustment can be finely made, however, as it takes a complete turn of the screw or more to give any noticeable change in the mixture furnished to the engine.

Care should be taken in making this adjustment. Primarily it is, of course, necessary to furnish the engine with the proper mixture so that all cylinders are firing at all times smoothly and positively. The adjustments should be made when the engine is warm but the operation cold should be taken into account by setting the mixtures as rich as possible and still fulfill any requirements for good engine operation in a warm condition.

The securing of good low idle operation of the engine is dependent on the proper coordination of the three adjustments which are provided so that despite variations in conditions a fine regulation can be obtained with the consequent desired operation.

The three adjustments are: the throttle synchronization, the throttle stop and the idle adjustment. The carburetors must be accurately synchronized together or the low idle will never be good under any conditions. The synchronization should be checked when the idling adjustment is being made and if not correct, regulated until it is so. If the pair of throttles of one carburetor are behind those of the other, all cylinders fed from that carburetor will have a weak exhaust compared to those drawing from the other.

After the synchronization of the throttles, the rest of the low idling adjustment is made by carefully regulating the individual idle adjustments and the throttle stops until the desired results are obtained.

The packing glands on the throttle shafts of the carburetor should be watched carefully. Some friction in these is unavoidable. This should be kept at the absolute minimum necessary to hold the desired pressure.

Holes are provided in the packing gland nuts for safety wire, and these should be utilized at all times. Otherwise there is danger of the nuts either coming loose entirely or else screwing up and binding the throttle shaft.

Lubrication System.—With lubrication system filled, inspect for oil leaks in tanks and lines particularly at

hose connections. Particular attention must be paid to keeping all hose clamps tightened securely. Double hose clamps should be used on all pressure lines.

Inspect for oil leaks on engine, with special regard to any external pressure lines.

Inspect pressure oil line from engine to pressure gauge on instrument panel.

Ignition System.—Inspect ignition wires to see that all connections are secure.

Inspect spark plugs for signs of oil. This may indicate a leaking gasket or a loose plug.

Cooling System.—With cooling system filled, inspect cooling system for leaks at hose connections, valves, water pumps, expansion tank, and heat exchanger.

General.—Clean the engine, removing all fuel, water, excess oil, dirt, or grit from the outside surfaces of the engine or its accessories.

Clean the sea water strainers.

Twenty-five-hour Period Inspection

Check all items in Daily Inspection and the following:

The distributor cap should be removed at regular intervals and the cap and rotor wiped and examined for cracks or chips. The wiring should be carefully inspected. If the contact points are oxidized or pitted, they should be cleaned with a clean, fine-cut contact file or stone. *Never use emery cloth or sandpaper to clean points,* since particles of emery or sand might lodge in the points and cause them to burn. Check the distributor cap plunger for wear, and the breaker points for general condition and proper clearance settings.

The contact point pressure is measured by hooking just back of the contact point with a spring gauge, and pulling in a direction vertical to the point surface with increasing tension until the points separate. The points should separate with 19–23 ounces pull. Adjustment is made by bending the contact spring slightly.

Check the distributor cam for tightness.

Put a drop of light engine oil on the two breaker lever hinge pins, and place a small amount of petrolatum on the breaker cam. Care should be taken not to place too large a quantity of lubricant on these parts as it may be thrown or may run onto the contact points when running and cause excessive burning of these contacts.

Clean the Cuno oil filter. Remove the six screws from the Cuno filter unit flange located on the forward end of the engine. Cuno filter element may be lifted out for cleaning. Do not turn the handle of the element while it is out of the engine as this will cause the filter discs to bind. Use either kerosene or a low grade clear gasoline to wash dirt from the element and from the filter recesses in the engines. When replacing the filter, be certain to make an oil tight joint between the filter flange and the engine. Tighten screws.

Drain and clean the fuel filter.

Examine the engine and engine bed for loose nuts and bolts.

Check storage batteries for proper level and state of charge. (1.240 suggested minimum gravity.)

Check general condition of all electrical apparatus and terminals.

Fifty-hour Period Inspection

Change the oil at the end of fifty hour period of operation.

Check timing of each distributor.

Synchronize distributor breaker points.

Check electrical circuit for loose connections, broken wires, etc.

Have condensers and coils tested.

Generator—Inspection

1. Remove the head band.

2. Inspect the commutator. If the commutator is dirty or discolored, it can be cleaned by holding a piece of 00 sandpaper against it while turning the armature slowly. Blow the sand out of the generator after cleaning the commutator. If the commutator is rough or worn, the generator should be removed from the engine and completely overhauled as outlined under "Overhaul."

3. Inspect the brushes. The brushes should slide freely in their holders. If the brushes are oil soaked or if they are worn to less than one-half of their original length, the generator should be given a tune-up inspection as outlined under "Overhaul Inspection."
(See page 33.)

Generator—Lubrication

The commutator end bearing should be given 3 to 5 drops of medium engine oil in the hinge top oiler located above the bearing.

Generator—Wiring

1. *Visual Inspection.*—Inspect all wiring from the generator to the regulator, from the regulator to the battery and from the battery to ground for worn or

frayed insulation, broken wires and for loose or corroded connections. Repair or replace any defective wiring.

2. *Voltage Drop Test.*—Run the generator and turn on lights so that the generator charges at about 10 amperes. With an accurate reading voltmeter, measure the voltage from the generator "A" terminal to the regulator "A" terminal, from the generator "F" terminal to the regulator "F" terminal, and from the regulator "B" terminal to the battery post. The voltage reading for any of these tests should not be more than .1 volt at the 10 ampere charging rate. At the same charging rate the voltmeter should show no reading when measured from the generator frame to the regulator base, the generator frame to the battery ground post or to the regulator base and the battery ground post. If larger readings are obtained, the high resistance should be eliminated.

Generator—Operation

1. Run the generator at about 10 to 15 amperes and note the commutator action. If there is excessive arcing between the brushes, and commutator, remove the generator for a tune-up inspection as outlined under "Overhaul Inspection." (See page 33.)

2. Test the regulator as outlined in the regulator specifications.

3. Replace the generator head band.

Starter Motor—Inspection

1. Remove the head band.

2. Inspect the commutator. If the commutator is dirty or discolored, it can be cleaned by holding a piece of 00 sandpaper against it while turning the armature slowly. Blow the sand out of the motor after cleaning. If the commutator is rough or worn, the motor should be removed from the engine for a complete overhaul as outlined under "Overhaul."

3. Inspect the brushes. The brushes should swing freely and should be in line with the commutator segments. If the brushes are oil soaked or are worn to less than one-half of their original length, they should be replaced as described under "Overhaul."

Starter Motor—Lubrication

Add three to five drops of medium engine oil to rear oiler.

Starter Motor—Wiring

Check the wiring for broken wires, frayed insulation and for corroded connections. Particular attention should be paid to the motor and battery ground connections.

Starter Motor—Starting Switch

Check the voltage drop across the starting switch during normal starting operation. This drop should not exceed .05 volts per 100 amperes.

Check and clean fresh water thermostats.

Remove and clean air cleaner.

Drain and flush carburetors. Remove drain plug in bottom of carburetor bowl and flush with aid of wobble pump.

Check intake and exhaust valve clearances and adjust if necessary. (See page 14.) Visually inspect all members of value operating mechanism.

Tighten cylinder head and cylinder block nuts.

Remove, clean, and inspect all spark plugs.

Check ahead, neutral, and astern reverse gear adjustments.

NOTES ON ENGINE TROUBLES

General Remarks

Difficulty in determining the exact cause of engine trouble will be encountered at times because of the number of sources to which a symptom may be attributed. For instance, faulty carburetion, ignition or lubrication, as well as cooling system trouble, or incorrect valve timing, will result in engine overheating, loss of power, faulty firing, etc. Also in many cases, ignition, carburetion, or fuel defects or a mechanical imperfection are manifested identically in missing or uneven firing. The best method of "trouble shooting," consequently, is to take the possible causes and eliminate them one by one, starting with the most probable.

To attain efficiency in this work, a knowledge of the construction and assembly of the engine and of the function of its various parts is of vital importance. In addition, it is necessary to know not only the characteristics of general troubles, their cause and effects, but also the trouble that may occur in the respective systems of the engine.

All "trouble shooting" requires careful thought and thorough attention to all possibilities. Jumping at conclusions is the most unsatisfactory way to locate trouble.

Starting Troubles

If the engine fails to start, the trouble may be due to one or more of the following:

1. Excessive priming.
2. Insufficient priming.
3. Lack of fuel supply.

4. Throttle opening incorrect. The throttle should be nearly closed until the engine starts to fire, and should then be opened slowly to the position where the tachometer will indicate approximately 800 R.P.M.

5. Defective ignition wire, fouled spark plugs, improper spark plug gap, improper breaker gap or defective breaker contacts, weak battery, incorrect ignition timing.

6. Incorrect valve clearance or valve timing.

7. Water in carburetor.

Lubrication System Troubles

An interruption of normal lubrication may result in damage to the engine. The oil pressure and temperature gauges will aid in the detection of this trouble.

Some of the defects causing "loss of pressure" are difficult to diagnose because they are all manifested usually by the same abnormal oil gauge readings. A few simple tests will locate the majority of them.

Lack of oil pressure may be due to one or more of the following:

1. Suction pipe clogged.
2. Cuno filter clogged.
3. Oil pump not primed.
4. Air lock in the pump or oil lines; air leak into suction line.
5. Oil too cold or too heavy to flow.
6. Broken oil pressure relief valve spring.
7. Empty oil tank.
8. Gauge defective.
9. Valve closed in suction line.
10. Excessive bearing clearance in which case an overhaul is necessary.
11. High oil temperature.

Excessive oil pressure may be due to:

1. Relief valve adjusting screw set in too far.
2. Defective oil gauge.
3. Grade of oil too heavy.

Fuel and Carburetion System Troubles

Backfiring is generally caused by defective carburetion, usually due to too lean a mixture, low grade fuel, or an engine temperature that is too low.

If any set of three cylinders fed by one intake header, or if either set of six cylinders fed by one carburetor, misses or cuts out in approximately the same manner, it is usually due to defective carburetion. Defective carburetion, however, may also cause missing or cut-outs in single cylinders. Often, water or other foreign substance in the jets, carburetor fuel passages, fuel lines or strainers, will cause intermittent missing of one or more cylinders. Clogged fuel strainers will give similar trouble.

When all cylinders cut out or misfire due to carburetion trouble, insufficient fuel supply to the carburetors is usually the cause.

Because of the fire hazard, backfiring is a dangerous condition, and every precaution should be taken to prevent it.

Insufficient fuel flow may be due to one or more of the following:

1. Fuel line valves not fully opened.
2. Defective fuel pumps.
3. Very low fuel level in tanks allowing the movement of the vessel to interrupt the suction occasionally.
4. Fuel lines bent or crushed, restricting the flow of fuel.
5. Main fuel filter, clogged or filled with water, restricting the flow of fuel.
6. Air or vapor lock in the fuel lines.
7. Restricted needle valve movement, caused by faulty float adjustment or other defects.
8. Water or ice in the carburetor, in the carburetor fuel strainers, or in the fuel lines.
9. Fuel passages clogged.
10. Insufficient fuel pressure.
11. Float level adjusted too low.

Excessive fuel flow is indicated by black smoke and "galloping" of the engine, and may be due to one or more of the following:

1. Float level adjusted too high.
2. Needle valve stuck open.
3. Foreign substance lodged between the seating surfaces of the needle valve and the seat.
4. Defective seating face of the needle valve or of the needle valve seat due to wear, damage, corrosion, or other causes.
5. Leaky float.
6. Excessive wear of the float fulcrum pins and supports.
7. Float sticking because of foreign substances lodged between the float and the float chamber wall.

Air leaks into the float chamber affect the mixture, particularly at low speeds.

A leak will also be caused by a cracked or broken priming line, loose fittings or air intake header plugs; or a cracked or defective intake header.

Backfiring through the carburetors may be due to one or more of the following:

1. Engine too cold.
2. Mixture too lean.
3. Low test fuel.
4. Defective ignition.
5. Intake valves held open as a result of one of the following: Sticking of the stem or of the camfollowers, broken or weak valve spring, insufficient tappet clearance, carbon or other foreign substance lodged between the valve and seat.
6. Intake valves or seats defective permitting the flame to enter the intake manifold.
7. Incorrect valve timing.
8. Excessive heating.
9. Excessive carbon.

Valve Troubles

Possible intake valve troubles are:

1. Worn or warped head or stem, causing a loss of compression.
2. Valves held open by the camfollowers sticking.
3. Tappet clearance insufficient or too great.
4. Valves sticking in their guides due to insufficient clearance, or to gritty substances between the valve stem and guide.
5. Broken or weak valve springs.
6. Valves improperly timed.

In addition to the defects listed above, the following troubles may be experienced with exhaust valves:

1. Burned valve head.
2. Valve stem sticking in the valve guide due to carbon or gummed oil.

Ignition System Troubles

It requires an experienced person in most cases to distinguish between ignition troubles and those caused by defective carburetion, because these troubles sometimes have identical effect on the operation of the engine. If efficient trouble shooting is to be accomplished, therefore, it will be necessary to observe very closely abnormal characteristics during engine operation to help determine the necessary steps to take to locate the source of trouble.

As a rule, when the engine stops suddenly during high speed and there is no "backfiring," it is due to ignition trouble caused by grounds, shorts, or an open circuit in the primary circuit, between the distributors and the battery.

If the engine apparently runs properly with the ignition switch in the "Both" position but stops immediately when one switch is cut off, the trouble is usually due to grounds, shorts of "opens" in the primary circuit of the distributor fed by the switch that was left ON. (The operator should make this test at frequent intervals.)

There is also the possibility that the secondary circuit of this distributor is defective or that the battery connections are defective.

Loss of Power

The full throttle speed of the engine will vary by 75 to 100 R.P.M. under different atmospheric conditions. Low power or uneven running may be due to one or more of the following:

1. Improper ignition or valve timing.
2. Any low or high tension troubles causing uneven firing or missing.
3. Improper mixture.

Engine Overheating

Overheating is usually indicated by the thermometer, with the possible exception of the overheating of one or a few of the cylinders. There is always the possibility, however, of a gauge being defective and registering inaccurately. Because of this, the operator should be constantly on the alert, not relying entirely on the gauge readings.

The operator should make it a practice of "feeling" at regular intervals along the water jackets of the exhaust manifold, individual cylinders and intake manifolds. In this way, he will become sensitive to the operating temperatures and any abnormal departures therefrom should be investigated. Engine overheating may be due to one or more of the following:

1. Loss of water.
2. Defective water pump.
3. Air trapped in water spaces due to improper venting.
4. Improper ignition timing.
5. Mixture too lean or too rich.
6. Preignition and/or detonation caused by the use of low grade fuel, hot spark plugs or incandescent material in the combustion chamber.
7. Any defect causing a lack of oil.
8. Insufficient cooling of the oil.
9. Improper valve timing.
10. Insufficient clearances, causing undue friction.
11. Clogged sea water strainers.

OVERHAUL AND ASSEMBLY

Time of Overhaul

It is recommended that the engine be completely overhauled after every 500 hours of operation. To determine this period requires a well-kept and accurate log of engine operating time.

It is again noted at this point that should it be necessary to order parts for the engine at any time, it is best to order them by both name and number.

It is very important that all personnel doing any work on these engines should be thoroughly familiar with the construction of the engines and with the information contained in this book.

At all times, considerable care must be taken to guard against chips or other foreign material getting into the oiling system of the engine proper or of any of its accessories.

All gasketed or smooth machined surfaces should receive special attention when handling to prevent scratching or other damage.

As a standard procedure, all major working steel members should be magnafluxed at every overhaul.

The overhaul should be carried out on one complete assembly at a time. All parts must be kept clean before assembling or adjusting.

Keep all parts from rusting.

Always use new cotter pins.

Be sure to remove all burrs.

Use a rawhide hammer for parts that would be damaged by a metal hammer.

If possible, during overhaul the engine should be mounted on a rotating stand.

Use new gaskets wherever needed.

Crankcase

The crankcase should be thoroughly washed with gasoline, particularly in all corners and pockets in the casting. After cleaning, the case should be dried, preferably by an air blast. Examine the casting thoroughly for cracks at all studs, webs, and keyways. Examine each bearing shell carefully and note the condition of the bearing metal. If the bearings are in good condition, do not touch them. Measure them to determine if they are out of round or worn. This is best done by measuring them in the case but a suitable fixture may be used to simulate the conditions of the bearings in the case. Be sure that everything is clean and that the correct bearing is in its correct place in the crankcase. Draw up the nuts to the same tension as if the shaft were in the bearings. (See page 17.)

The measurements should be taken by a person who is using the measuring tools constantly. Diameters should be taken to the nearest quarter thousandths of an inch (.00025") and recorded for each bearing. Do not measure across the joint of the bearing, but take the measurements about ¼" from the joint. Take four (4) readings for each bearing. Take two such joint measurements (one at either end) and two additional readings at right angles to these. The bearings should be measured with a small inside micrometer or a pair of inside calipers and a micrometer caliper.

Be sure that the bearing shells are clean and that all oil holes and passages line up and are free of dirt, chips or other foreign matter.

Crankshaft Assembly

Remove the crankshaft oil retaining plugs, wash and dry the crankshaft and replace the crankshaft plugs in their original places. Be sure that all drilled oil passages are thoroughly cleaned out.

Measure all main journals and crankpins, measuring to the nearest quarter thousandth of an inch. Record these measurements along with those of the main bearings for reference to determine the clearances.

When ready to assemble the crankshaft in the crankcase, all bearings and journals should be well lubricated with oil such as is used in service, and the shaft placed in the bearings. Be sure that the oil and bearing surfaces are clean. Do not try to force the shaft or turn it before both halves of the bearing are assembled and tightened by the long through bolts located either side of the main bearing shells. Be sure that the nuts are pulled up to the required torque (see page 17) and that each one is securely cotter pinned.

Pistons and Piston Rings

Remove the carbon from each piston head and the piston ring grooves, being careful to avoid scratching the piston, especially in the ring grooves. To clean out the ring groove, use a tool that has the corners rounded to conform to the fillet at the bottom of the groove. The piston should have no rough spots on it, and if any appear, stone them smooth with a fine grit stone. See that the oil holes are clean.

The piston rings should be replaced. To check for gap clearance, place the piston in the cylinder, and place the ring in the cylinder using the piston to line the ring up square with the bore. Measure the gap with a feeler gauge.

Piston pins should not be out of round more than .001", and should be an easy hand push fit after any carbon that may be in the piston pin bearing is removed.

Connecting Rod Assemblies

Clean and examine the connecting rod assemblies. If the appearance of the bearings is good, assemble the bearing caps (see page 17) for proper torque on the rods and measure the bearings. Record the measurements and compare with the crankpin dimensions.

The piston pins should be an easy push fit in the piston pin bushings.

The link pin assemblies should be examined for loose oil tubes, and for wear.

All corresponding parts except the link pins and bolts are numbered. The locking bolts for the link pins locate the pins in their correct positions. The locking bolts should be tight and the nuts cotter pinned. The bolt goes in the rod with the nut down.

Oil the connecting rod bearings and the crankpins. There are two methods of asembling the connecting rods and the crankshaft in the crankcase. The best of these is to set the crankshaft in the lower crankcase and assemble the connecting rods upon it. The upper case is then assembled over the two, care being taken to pass the proper rods carefully through the upper deck holes. The cases are then bolted together. This method usually requires the assistance of several persons to support the connecting rods and lower the crankcase at the same time. The alternate method is to assemble the crankshaft in the crankcases and bolt them together. The connecting rods are then assembled onto the crankshaft. To do this, it is best to put the connecting rod assembly through the hole in the deck in which the master rod will operate, the articulated or short rod being put through first. Then the short rod can be moved under the crankshaft and placed in the opposite deck hole. Be careful to avoid scratching the crankpins. Bring the bearing up to the crankpin, and put the cap over the bolts. Put on the nuts, and draw the bearing together gradually and evenly. When ready to run, the master rods should be on the right hand side of the engine (link rod to lead over top dead center). Be sure that all nuts are securely cotter pinned.

Cylinder Blocks

The cylinder blocks should have the carbon removed and should be washed. Look at the cylinders to see if any of them are scored or otherwise marred. If any cyinders are rough, they should be stoned or lapped smooth. If they are badly scored, worn, or excessively out of round, the replacement work should be done at the Vimalert factory or at a service station equipped with the proper tools.

Oil the cylinder walls with clean engine oil immediately after cleaning.

If necessary to grind the valves, care must be taken to remove all grinding compound after the grinding operation. The valves should be ground at an angle of 45°, using as light a cut as possible. After cleaning, assemble the valves and valve springs. Assemble the lock rings on the valve stems. The split cone nut should be screwed on the stem until the top edge of the valve spring washer is $1\frac{3}{16}$" from the top machined surface of the head. After assembly, be sure that there is sufficient clearance between the adjusting screw and the camshaft.

If any of the camfollowers have the split ends or the locking screws bent, replace them. Assemble the camfollowers in their proper positions.

Be sure that both lock rings for each piston pin are in their respective grooves.

If a number of mechanics are available, the cylinder blocks are easily assembled by setting the crankcase so that the cylinders may be held horizontal and slipped on over the pistons, otherwise vertical assembly of the cylinder blocks is recommended.

Oil the pistons and clamp the piston rings of pistons No. 3 and 4 with brass ring-compressing clamps. Turn the crankshaft until the above pistons are nearly at the top of the stroke. Now the cylinders may be slipped over these two pistons until the piston rings are all in the cylinders. Then remove the clamps and use them for clamping the rings of pistons No. 2 and 5. If these pistons do not take a position far enough beyond No. 1 and 6 to allow the rings to enter before the latter pistons are ready to enter their respective cylinders, the crankshaft should be turned slightly to remedy this condition. The cylinders should not be slipped over pistons No. 2 and 5 until the rings are in the cylinder, and then the brass clamps moved to pistons No. 1 and 6. Remove the clamps after all of the piston rings have entered the cylinders and slip the cylinder block down over the studs. Put at least four (4) nuts with lock and flat washers on the studs, so that the cylinder assembly cannot move.

Do not assemble the pistons on the link rods until the master rod block is assembled on the engine.

It is recommended that the following procedure be carried out in tightening the cylinder hold down nuts; tighten the nuts on the end studs (long ones) in the Vee, and then tighten the corresponding nuts on the

outside of the block. This will draw the cylinder block down evenly. Turn the engine so that the same procedure can be carried out with the right hand block.

Tighten all cylinder hold down nuts evenly.

Put the intake spark plugs in tight.

Put on the oil tube that supplies the camshaft bearings and lock the cap screws with locking wire (.042" diameter soft iron wire, No. 19 B.W. Ga.).

Cover the intake manifolds so that no dirt or foreign matter can enter the engine.

Carburetion Assembly

The carburetion assembly should be disassembled and checked. To reassemble the carburetors, assemble the Y pipes and other equipment to complete the carburetion assembly as it was when removed from the engine. Leave the screws or nuts fastening the Y pipes to the carburetors loose.

Uncover the intake L manifolds. Be sure the manifolds are clean, then fasten the carburetion assembly in place. Be careful to avoid springing any parts. Cover all openings where dirt can enter. Tighten the cap screws or nuts holding the carburetors to the Y pipes.

Carburetors

The carburetor should be almost completely disassembled so that the condition of every part can be determined. This requires a thorough knowledge of the carburetor and painstaking attention to every detail of disassembly, examination and reassembly.

Particular care should be taken to see that gasket surfaces are not injured.

Care is required for the proper assembly and disassembly of the float mechanism. This is made of sturdy construction to stand hard service, but it is necessary for proper operation that it be assembled with the pivots accurately lined up, and the needle in its proper location at all positions of operation so that there is no tendency to bind. Be certain that the float does not rub on the carburetor walls.

To disassemble the carburetor, it is first necessary to remove the nine fillister head screws and the two castellated nuts which hold the two halves together. The screws are placed around the outside of the carburetor and the nuts are on studs which are located at the front and rear of the juncture of the two barrels, and fasten in the lower half.

If these halves stick together, they may be loosened with a few light blows from a rawhide mallet on the lower half, holding the upper half securely in one hand.

The venturis are held in place by shoulders which fit into grooves in the carburetor body. These shoulders and grooves are at the parting surface, and separating the halves allows the venturis to be removed. The right venturi, however, has the suction jet for the mixture control passing through it, and this must be taken out before the venturi can be removed from the upper half.

Unscrew the two plugs in the bottom of the main discharge nozzle bosses. Unscrewing the accelerating well screw will allow the removal of the main discharge nozzle proper and the accelerating well stud.

After these are out, the accelerating well stud should be unscrewed from the main discharge nozzle.

The floats are placed in the float chamber separately, and both are clamped rigidly to a common pivot shaft. To make this disassembly, the float needle valve must first be taken out. This is done by unscrewing the large hexagon headed seat cage directly above the needle valve, unscrewing the needle valve seat, and working the needle valve upward through the exposed hole. Care must be taken with the valve seat (it will be found to be very tightly in place) both to see that the screw driver slot is not injured and to keep intact the gaskets under the seat. These gaskets determine the float level, and if put back in place exactly as removed, the float level will be the same.

Remove the small $\frac{7}{16}$"-24 thread plug under the needle valve seat. A small screw driver can be inserted through this hole to loosen the small clamp screw which fastens the arm of the rear float to the float pivot shaft.

The front float arm is unloosened in the same manner except from the top, the plug being in a position corresponding to that of the float needle seat in the rear. After loosening the float arms, the two pivot bearings in the end should be unscrewed.

It will be noted that the pivot shaft is hollow, and has in its ends a length of 10–32 female thread. Any screw or bolt having this thread can be used to screw into one end of this for handling. The shaft should be pulled toward the end in which the screw is being used until the float arm of the float in the other end is clear of the shaft. This float should then be removed and the shaft moved in the other direction until the other float is clear and can also be removed.

A 10–32 screw can be screwed into the tapped hole in the end of the pivot shaft to aid in its handling.

There is ample clearance between the hexagon on the shaft and the hexagonal hole in the float lever if the two are properly lined up with each other. If they are not lined up, the lever binds on the shaft and prevents it from moving in either direction. The best method is to hold the float with the fingers of one hand while working the pivot shaft with the other.

In replacing, particular attention should be paid the pivot shaft plugs. These act not only as bearings for the pivot shaft, but serve also to limit the end play of the float and shaft assembly. This end play should be the minimum consistent with the free operation of the float.

Remove the idle air bleeders and the idle tubes by unscrewing them from the upper half. The idle metering jets are unscrewed from the bottom of the lower half.

See that all drilled passages are open.

The mixture control valve is open to inspection when the cover plate is removed by unscrewing the small fillister head screws. If the mixture control valves are removed, mark carefully as each is individually fitted and they are not interchangeable.

If the throttle valve fits accurately, and the throttle shaft works freely in its bearings, it is not necessary to remove these; in case of removal, the throttles should be marked carefully so that each throttle is returned to the proper barrel with the proper face up and all points on the circumference in exactly the same location as before removal.

The assembly of the carburetor is just the reverse process given above with the following addition: After the assembly of the lower half, the float level should be checked, and if not right, made so.

Be sure that all gaskets are in place.

Check carefully to see that the venturi shoulder does not hold the two halves apart. The assembly of the two halves is best made by having the venturis in in place in the upper half as the assembly is started, making certain that the venturis are in the proper position to let the slots in the bottom fit over the main air bleeder arms.

Three points are of vital importance in the reassembly of the carburetor. They are:

The Float Level.—The level should be exactly correct with the fuel and operating head used in actual service, and there should be no "creeping" of the level.

The Main Body Gasket.—This should be in perfect condition. If the gasket is torn at any point around the float chamber or any of the mixture control drillings, it will not only allow fuel to seep out of the carburetor, but will seriously interfere with the mixture control action. If torn or imperfect around the idle tubes, it will cause poor idling operation and even cause the engine to cease firing entirely. If the gasket allows any connection between idle tubes and the float chamber, the engine will not run between 600 and 1200 r.p.m.

The Idle Discharge Jets.—These should fit perfectly in place without forcing and should rotate freely. They are different in the right and left barrels, and each must be returned to its proper side.

Generator—Overhaul Inspection

A. Remove the generator from the engine and take off the head band.

B. Inspect the commutator. (See page 26 on inspection.)

C. Brushes.

1. *Inspection.*—Each brush should slide freely in its holder and should be free from oil and dirt. Brushes that are oil soaked or are worn to less than one half of their original length should be replaced.

To install new brushes, remove the brush lead screw and lift the brush arm. Replace the old brushes and securely fasten the brush lead. Make sure the brush is turned so the beveled face fits the commutator. Check the brush alignment to make sure the brush edge is parallel with the commutator segments. If the alignment is off or if the brushes do not slide freely, the commutator end plate should be inspected as described under "Overhaul."

After new brushes are installed, they should be sanded to make sure of the proper fit on the commutator. To sand brushes, cut a strip of 00 or 000 sandpaper the exact width of the commutator. Slip this strip under a brush and pull so that the brush is forced against the holder. Be careful not to break the edge of the brush. Repeat the sanding on the other brush.

2. Check the brush spring tension. Measure with a spring scale hooked in the hole in the end of the brush arm. Pull the scale on a line parallel with the face of the brush, and take the reading just as the arm leaves the brush. Brush spring tension should be between 55 and 65 ounces with new brushes.

If the pressure is too great, the brushes and commutator will wear excessively while if the tension is too little, there will be a tendency to arc at the commutator.

3. Run in new brushes. New brushes should be run in to make sure of a perfect brush fit before output tests are made on a generator. To run in new brushes, the generator should be run under load long enough to secure a perfect brush fit.

D. Check armature end play. Armature end play should be held between .003" to .010". If the end play is too great, it can be reduced by installing thrust washers on the armature shaft just inside of either end

head. Make sure when installing thrust washers that the brushes are correctly centered on the commutator.

E. Bench Test:

1. Field Coil Draw.—1.49 to 1.64 amperes at 13.0 volts.

2. Motorizing Draw.—3.30 to 3.70 amperes at 13.0 volts. This test is made with the field terminal connected to ground.

3. Output Test—4.0 amps., 14.6 Volts at 970 max. R.P.M., 30.0 amps., 14.6 Volts at 1415 max. R.P.M.. 30.0 amps., 15.0 Volts at 1420 max. R.P.M.

F. Reassembly to Engine.—Remount the generator on the engine, and follow the 50 hour inspection from lubrication to end.

Overhaul.—To completely overhaul the generator, it should be removed from the engine and taken to the bench.

A. Disassembly:

1. Remove the head band.

2. Remove the drive gear and shaft nut.

3. Remove the ventilating fan.

4. Remove the commutator end bearing cover and gasket.

5. Remove the air deflector from the commutator end head.

6. Remove the commutator end shaft nut and bearing.

7. Remove the frame screws.

8. Lift the commutator end head off the generator.

9. Lift the drive end and armature out of the frame and field.

10. Press the armature shaft out of the drive end head.

B. Inspection:

1. *Armature.*—Inspect the armature and commutator for evidences of wear. Inspect the insulation and the soldering to make sure all coils are in proper working order. Check the windings for ground, shorts and open circuits.

If the commutator is rough or worn, it should be turned down in a lathe. When turning, mount the shaft on the bearing seats and not on the shaft centers. After turning, undercut the mica clean and squarely to a depth of 1/32 inch.

If the solder has been thrown, it should be resoldered and any other visible fault should be repaired. It is recommended that faulty armatures be replaced and no attempt made to repair armatures with internal faults.

2. *Frame and Field.*—Inspect the insulation on the field coils and terminal posts, and replace any faulty part. Check the field coils for grounds and for open circuits. Inspect the leads for broken wires and for frayed insulation. Check the armature terminal for grounds.

If the field coils are faulty and must be replaced, remove the pole piece screws. Assemble the new coils on the pole pieces and tighten securely with pole piece screws that have been dipped in boiled linseed oil. As the screws are tightened, the frame should be struck with a rawhide hammer a few times to settle properly the pole pieces.

3. *Commutator End Plate.*—Inspect the brush holders to see that they are not bent or corroded. Check the insulated brush holder for grounds.

Clean the commutator end plate, making sure the oil pocket and bearing are thoroughly clean. Inspect the bearing for wear and replace if badly worn.

Repack the bearing ½ full with a high melting point grease.

4. *Drive End Head.*—Disassemble and clean the bearing and retainers. Inspect each part for wear or failures.

Pack the ball bearing ½ full with a high melting point grease and reassemble the drive end head.

C. Assembly:

1. Assemble the drive end head on the armature.

2. Assemble the drive end head on the frame and field, making sure the dowel pin is in place.

3. Assemble the commutator end head on the frame and field, making sure the dowel pin is in place.

4. Assemble the frame screws.

5. Assemble the commutator end bearing and retainers.

6. Assemble the air deflector and commutator end bearing cover.

7. Assemble the fan, oil thrower, drive gear and shaft nuts on the generator.

8. Assemble the brushes in their holders, and connect the leads.

D. Follow the "Overhaul Inspection" from C2 to end.

Voltage Regulator

Note.—Before any work is done on the regulator, the following conditions should be carefully checked and corrected if at fault:

1. Wiring from generator to regulator properly connected.

2. High resistance connections in the charging circuit. This should be checked with an accurate reading voltmeter and inspected mechanically for poorly soldered terminals and loose or corroded connections.

3. Generator performance without the regulator in the circuit operating according to specifications.

4. That the regulator is the one designed for the generator with which it is operating. These regulators will function satisfactorily only when installed with the generator designed to operate it. Also battery condition affects regulator operation. An old battery, one partially charged, or one subjected to excessive heat will cause high charging rate; while one subjected to excessive cold, hard plates, high resistance separators and sulphation will cause low charging rate. The open circuit terminal voltage of the battery as well as its specific gravity should be checked. The condition of the battery as to capacity, leakage, etc., should be checked by separate test as specified by the battery manufacturer.

The equipment needed for testing on the engine includes an accurate indicating ammeter graduated in 1 ampere readings with heavy short leads, an accurate indicating voltmeter graduated in .1 volt readings, and a reliable thermometer.

The resistance of the test ammeter must not exceed .1 volts at 10 amperes or .01 ohms. Instruments which have resistance higher than this will make it impossible to check or adjust the units with the necessary accuracy.

The drop in voltage from the regulator to the battery or from the generator to the regulator must not exceed .1 volt when the generator is charging 10 amperes. At this same charging rate, the voltmeter should not show a reading when measured from the regulator base to the battery ground post, the generator frame to the regulator base or from the generator frame to the battery ground post.

Connections: Disconnect the wire from the regulator "B" terminal. Connect one ammeter lead to the regulator "B" terminal and the other ammeter lead to the lead removed from this terminal. One voltmeter lead should be connected to the regulator "B" terminal on the regulator side of the ammeter connection, while the other voltmeter lead is to be connected to the terminal marked "GD" or to the base of the regulator. (If the connections are not made in this manner, false readings will be obtained due to voltage loss in the current connections.)

The thermometer should be placed so that its bulb is approximately two inches from the side of the regulator. It must not touch the regulator.

Battery.—This must read 1.275 to 1.280 specific gravity. If the battery is discharged, substitute temporarily for test purposes a fully charged battery in good condition of the same type and capacity.

Test.—Start the engine and set the throttle for a generator speed of approximately 2500 r.p.m. Run the engine for not less than 15 minutes before taking meter readings. With a generator charge of 10 amperes, the voltmeter should show a reading according to the specification figures given for the regulator under test at the temperature shown by the thermometer. With readings according to these figures, the voltage regulator unit can be passed as functioning correctly.

To test the current limiting regulator, the same connections as noted above are used. Add an electrical load of a current value in excess of the amperes noted on the name plate of the regulator at a point between the ammeter and the battery. (This load may consist of a bank of standard head light bulbs or a carbon pile rheostat.) If the current limiting regulator is functioning correctly, the test ammeter will show a reading of the maximum amperes shown on the name plate of the regulator with an allowed variation of plus or minus 5%.

If the unit does not operate according to specifications, it should be removed and thoroughly checked and adjusted.

Adjustment.—Note: The cover must be on the regulator when taking readings or when the unit is being heated by operation prior to taking readings. This is necessary due to the fact that the cover forms part of the magnetic circuit and also helps retain the heat.

Heat the regulator by operating it for 15 minutes with the generator charging 10 amperes. While heating the regulator, have the cover on the unit.

1. Check circuit breaker operation.

To test, connect the ammeter in series between the battery and the "B" terminal. The voltmeter is connected to the "A" terminal of the regulator and to ground. Be sure that the voltmeter connections are on the regulator side of the ammeter connections to avoid losses due to poor connections.

To adjust the contact closing voltage adjust the armature spring tension by bending the bracket which holds the lower end of the spring.

To adjust the contact opening amperage, adjust the contact gap by raising or lowering the stationary contact.

After each adjustment, replace the regulator cover and again test the circuit breaker operation.

There should always be at least .5 volts less voltage at which the circuit breaker closes than the voltage at which the voltage regulator operates.

2. Check voltage regulator unit.

In making this test, an accurate voltmeter must be used. It is to be connected to the regulator "B" terminal and to ground.

To adjust its operation, increase or decrease the armature spring tension. Increasing the spring tension increases the voltage at which the unit will operate, while decreasing the tension decreases its operating voltage. This is done by bending the bracket which holds the lower end of the spring.

Replace the cover after making each adjustment. Take a flash voltage reading by stopping the generator and noting the maximum voltage reading when the generator is restarted.

3. Check current limiting regulator unit.

Connect the test ammeter in series between the regulator "B" terminal and the battery.

By increasing the generator output with a lamp bank or other suitable resistance connected across the battery on the battery side of the ammeter, the ampere output should be as noted on the name plate of the regulator under test with an allowable variation of plus or minus 5%.

Its operation is adjusted by varying the armature spring tension. This is done by bending the bracket which holds the lower end of the spring.

It is necessary that after all adjustments are made, a final flash test be made on all three units by stopping the generator and taking a reading immediately after restarting and bringing it up to the operating speed and amperage.

Starter Motor

Overhaul Inspection.—This inspection should include all of the items of the 50 hour inspection except that the motor should be removed from the engine, and the work done on the bench.

The motor should be cleaned and tested for no load current draw and lock torque on the test bench before reassembling on the engine.

The no load specifications are: 50 max. amperes, 5.5 volts, 2980 min. r.p.m.

The stall torque specifications are: 555 amperes, 3.0 volts, 18.0 ft. lbs.

Overhaul.—For a complete overhaul the motor should be removed from the engine and taken to the bench for the following operations:

A. Disassembly:

1. Remove the head band.

2. Disconnect the field coil leads at the brushes.

3. Remove the frame screws.

4. Lift off the commutator end head, being careful not to let the brushes snap down and become chipped.

5. Lift the armature and drive end head out of the frame and field.

6. Remove the gear and Woodruff key from the armature shaft.

7. Press the shaft out of the drive end head.

B. Inspection:

1. Armature:

Inspect the windings to see that they are firmly in place and are properly staked to the commutator. Inspect the insulation to see that it is not frayed or worn. Check for opens, shorts and grounds, and inspect the bearing seats for wear.

If the commutator is found to be rough, it should be turned down in a lathe. When turning, mount the armature on the bearing seats and not on the shaft centers.

Check the eccentricity of the commutator with a dial indicator and with the armature bearing seats mounted on V blocks. The commutator should be true within .0003 inch indicator reading.

Do not undercut the mica segments after turning the commutator.

2. Commutator End Plate:

Inspect the brushes to see that they are not oil soaked and are not worn to less than one-half of their original length. Replace the brushes if necessary, making sure they are firmly mounted.

Inspect the brush holders to see that they are not bent or out of alignment.

Inspect the bearing, and if found to be worn excessively, replace the end plate.

3. Frame and Field:

Inspect the field coils and terminal post insulation for grounds and check the field coils for open circuits.

If it is necessary to replace the field coils, remove the pole piece screws and install the new coil on the pole piece. Dip the pole piece screws in boiled linseed oil before assembling, and tighten securely. Hit the frame a few sharp blows with a rawhide hammer as the screws are tightened to align properly the pole pieces.

4. Drive End Head:

SUPPLEMENT TO INSTRUCTION MANUAL ON VIMALERT V–1150–1 MARINE ENGINE

With special reference to engines furnished on Army Contract #W33–092–tc–1019 Design #385

Read diligently and absorb carefully all information contained in *both* sections of this manual.

This supplement covers changes such as addition of radio shielding and addition of special angle iron engine mounts. (See photographs on succeeding pages.) It will be noted that advantage has been taken of the addition of the angle iron mounts for mounting the starter relay and one shielded ignition coil on the right side and the voltage regulator and the other shielded ignition coil on the left side.

Although these engines are being used with Panish reverse gear and throttle controls, these controls are not shown on the photographs but are furnished separately to the boat builder by Panish Controls. However, these controls are indicated on the installation drawing shown in this supplement. Refer to the installation drawing for installation dimensions and data.

The new weight of the engine including all components shown on the new photographs is approximately 1650 pounds.

The new spark plugs have integral radio-shielding. Referring to wiring diagram (facing page 12), master ignition switch 11N446 is no longer used. Fuse 11N465–1 has been removed from the location shown and is now installed in the line between the ammeter and starter relay. This line is marked No. 8 size wire.

In addition to the list of standard equipment shown on page 16, a special offset screw driver for turning the valve clearance adjusting screws and a special wrench required for locking same are being furnished with each pair of engines.

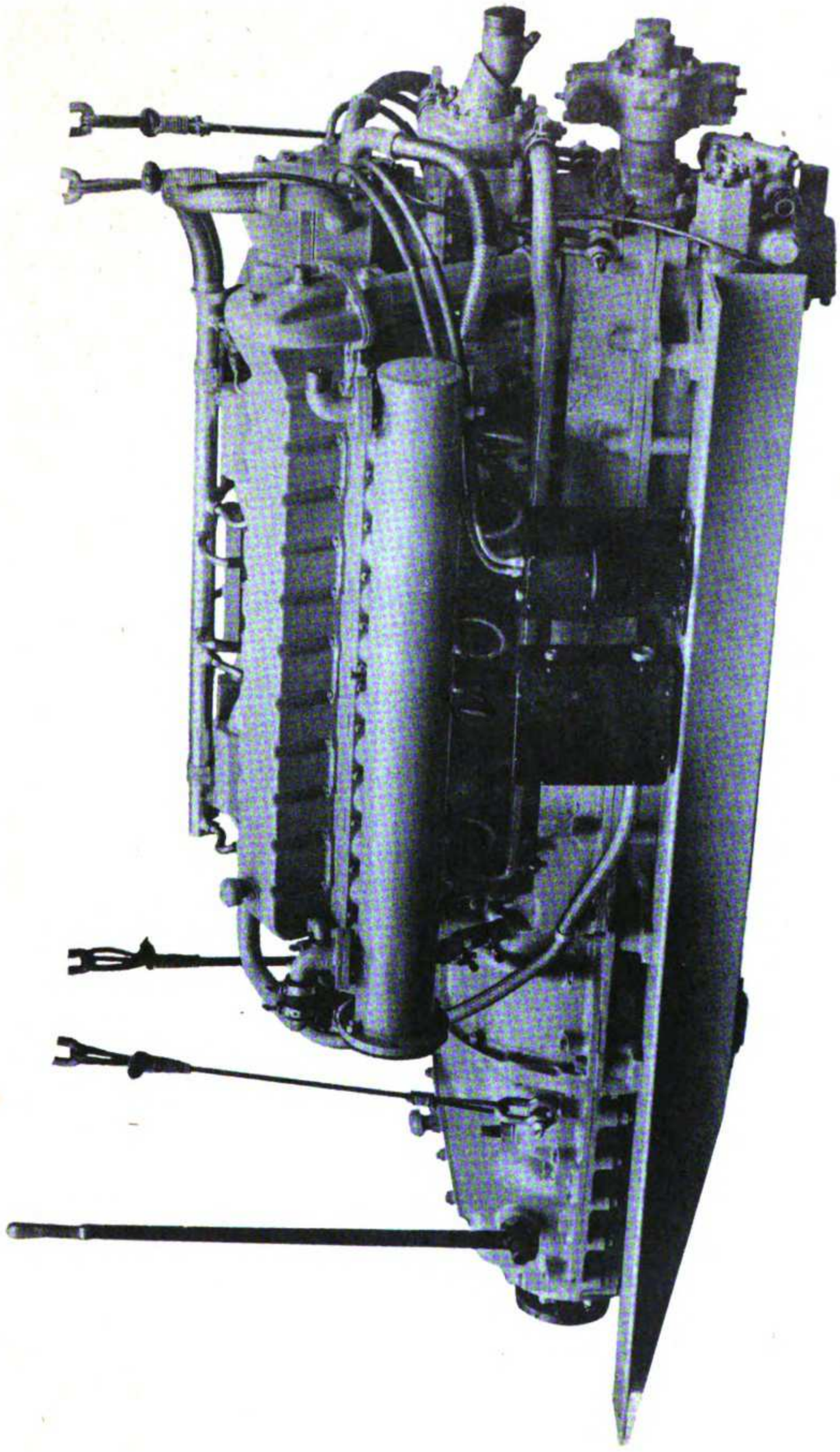
The following additional points will prove helpful in connection with actual operation of the engines:

1. In addition to the list of possible causes for engine overheating given on page 29, it is obvious that clogged sea water strainers will cause immediate engine overheating. All water, fuel and oil strainers must be cleaned regularly as specified under "Service Inspection and Maintenance."

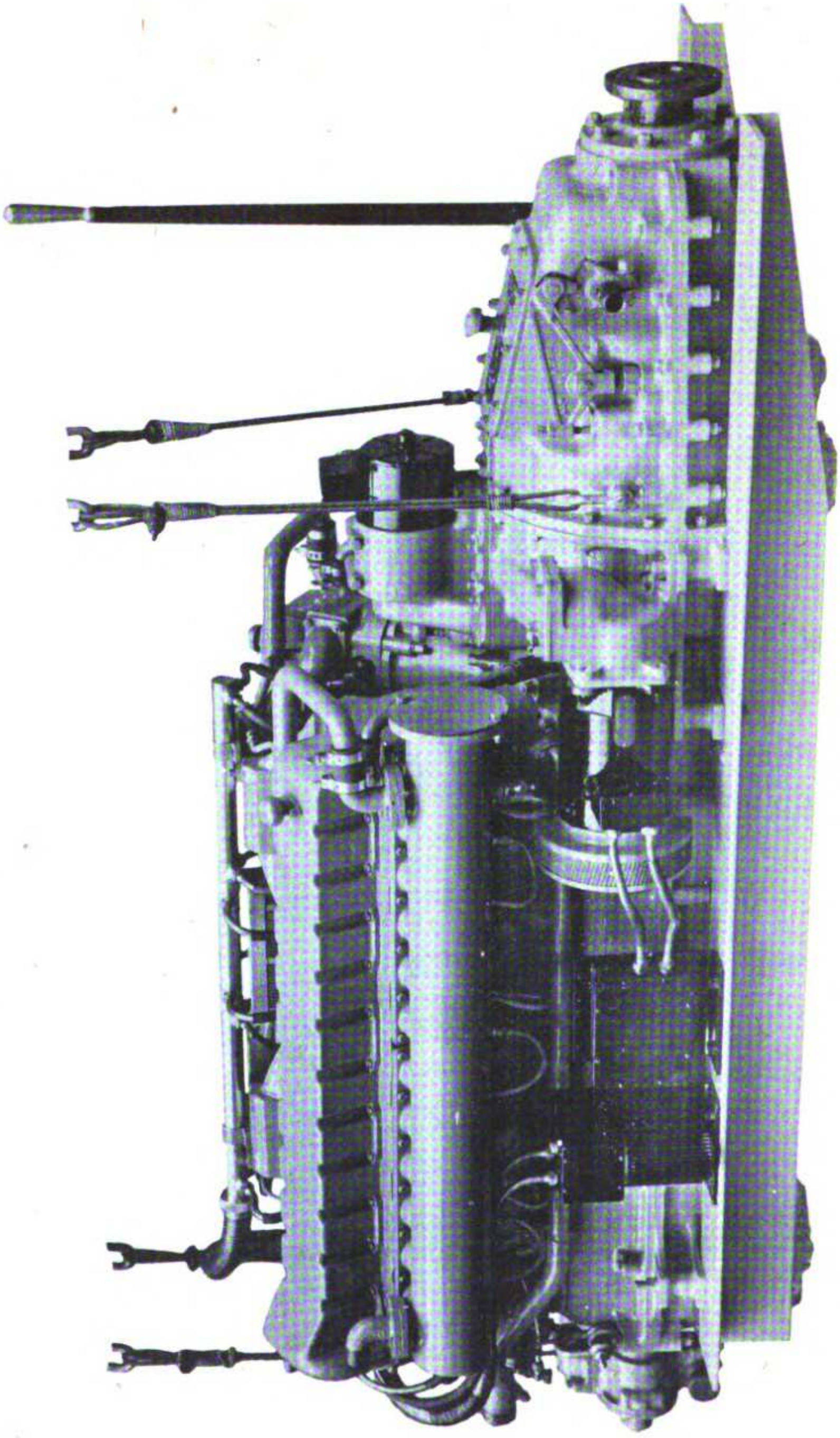
2. Movement of the oil within the oil tank in rough seas tends to uncover the oil outlet to the engine. For this reason it is important to keep the oil tank not less than one-half full at all times.

3. Starting in cold weather may be facilitated by not turning the ignition switch ON until after cranking has begun.

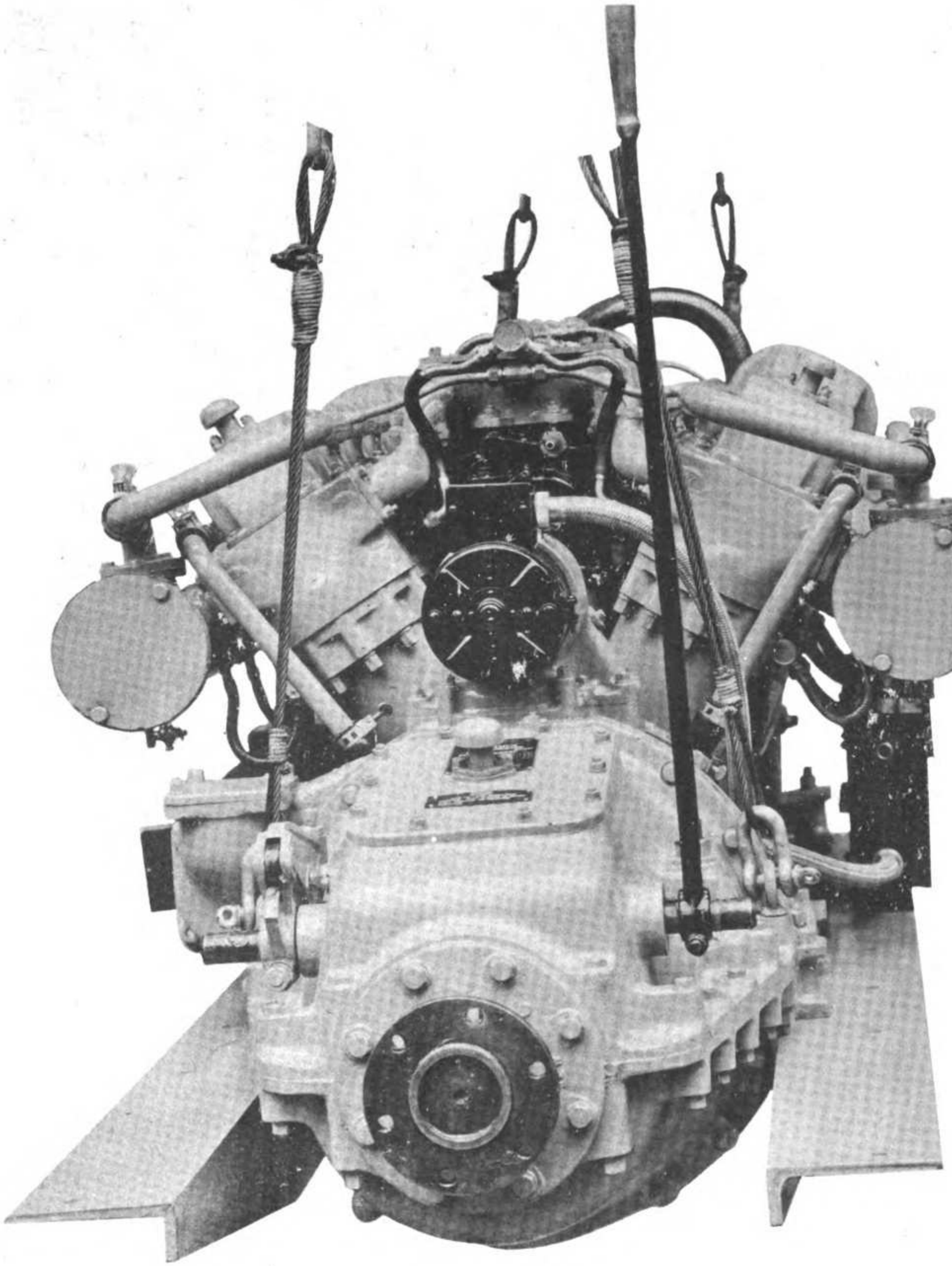
4. When operating the wobble pump for pumping gasoline into the carburetor for initial starting in a new installation, it is important that the fuel pressure on the fuel gauge on the instrument panel should not exceed 5 to 7 pounds per square inch. Violent operation of the wobble pump will flood the carburetor and, should the pressure in the fuel line be greater than 10 pounds, which is the maximum gauge limit, the fuel gauge may become defective and read erratically thereafter. Excess fuel from flooding, drops into the air intake scoop and then drains into the drip pan or equivalent container provided by the boat builder. If an attempt is made to start the engine with this excess fuel in the scoop, a fire may start in the scoop if the engine backfires and does not continue to run. This fire usually goes out immediately but, to be safe, it is best to turn the ignition switch OFF, open the throttle and crank the engine immediately with the starter to suck the fire into the engine. Then the engine can be started in the normal manner. Normally there will be ample fuel in the carburetor bowls and starts can regularly be made without the use of the wobble pump.



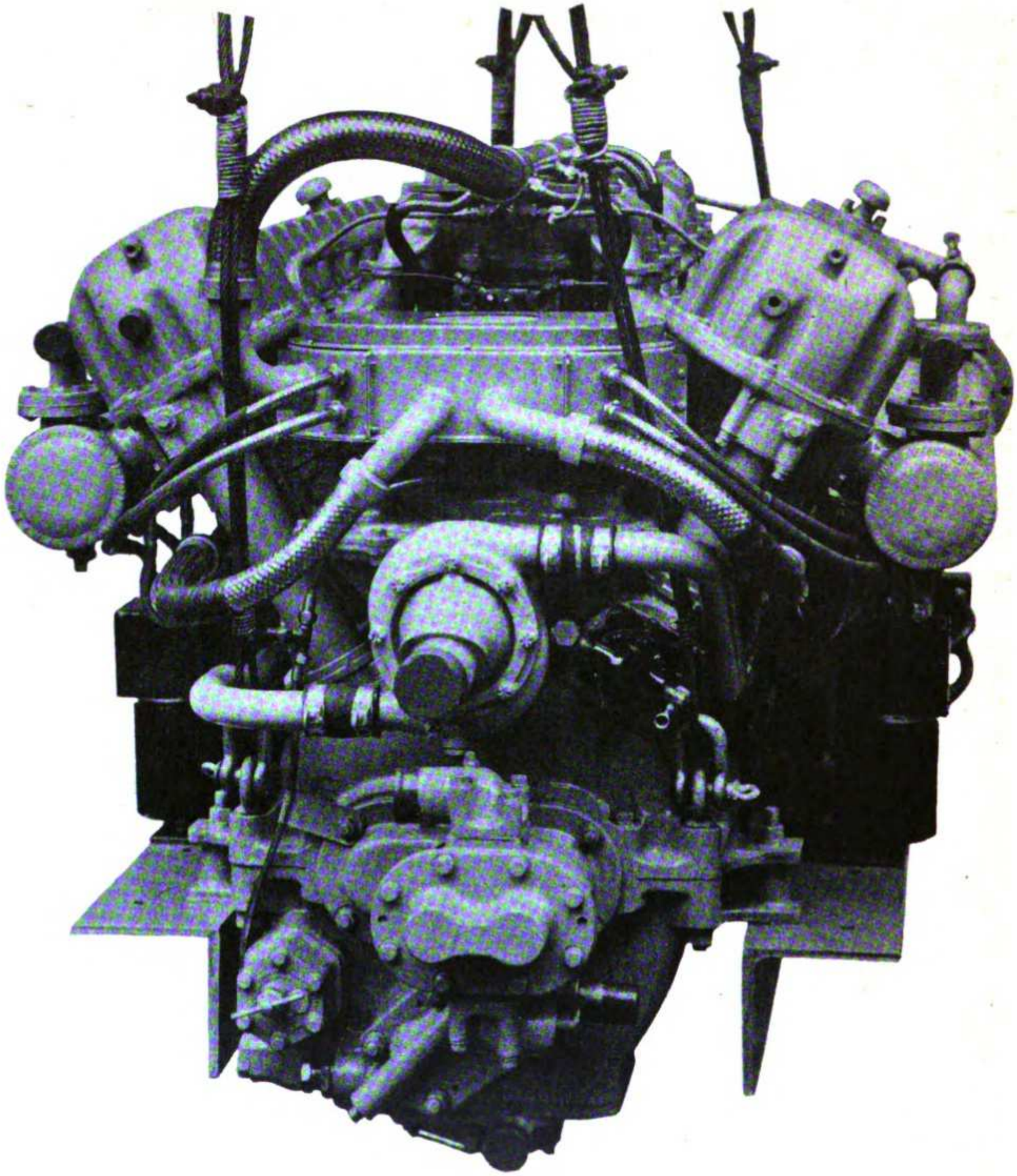
V-1150-1 ENGINE WITH SHIELDING—RIGHT SIDE VIEW



V-1150-1 ENGINE WITH SHIELDING—LEFT SIDE VIEW



V–1150–1 ENGINE WITH SHIELDING—REAR VIEW



V–1150–1 ENGINE WITH SHIELDING—FRONT VIEW

Bendix Drive

Part No.	Description	No. Reqd. per Engine
11B156	SHAFT ASSEMBLY-BENDIX DRIVE....	1
11C136	Gear	1
11B137	Shaft	1
11A613	Pin	1
11N427	BENDIX ASSEMBLY	1
11N427–1	Screw	1
11N427–2	Lock Washer	1
11N427–3	Spring	1
11A126	Bearing—Small	1
11A127	Bearing—Large	1
V–1105	Cotter Pin	4
25N2459	Nut—⅜ 24 Slotted.....	4
V–1109	Washer	4

Camshaft Assembly

11W1026–A	CAMSHAFT ASSEMBLY—EXHAUST..	2
11W1027	Camshaft—Exhaust	2
11N721	Plug—¾—20 Hex.	3
11N662	Pin—3/32	2
11N729	Screw—10-32 Fillister HD.....	2
25N2412	Lock Wire—.056	2
11W1024–A	CAMSHAFT ASSEMBLY—INTAKE....	2
11W1025	Camshaft Intake	2
11N721	Plug—¾—20 Hex.	4
11N662	Pin—3/32	4
11W1053	BEARING ASSEMBLY — CAMSHAFT FRONT	2
11N667	Stud—¼	2
V–1107	Washer—¼ Plain	2
25N2457	Nut—¼ Slotted	2
11W1055	Cap	2
11W1052	Dowel	4
11W1054	Bearing	2
11W1050–B	BEARING ASSEMBLY—CAMSHAFT. 2, 3, 4, 5, 6.....	10
11N667	Stud	10
V–1107	Washer—¼ Plain	10
25N2457	Nut—¼ Slotted	10
11W1055	Cap	10
11W1052	Dowel	20
11W1051	Bearing	10
11W1040–A	CAMFOLLOWER ASSEMBLY	24
11N678	Washer—#12 Lock	48
11W1049	Camfollower	24
11W1005	Screw	48
11N728	Screw—#12 SQ. HD.....	48

* As Required

Camshaft Upper Drive

Part No.	Description	No. Reqd. per Engine
11N865	CAMSHAFT DRIVE ASSEMBLY—UPPER LEFT BANK	1
11A262	Gear Assembly	1
11W1042	Gear	1
11N699	Nut	1
11N660	Pin—Taper	1
11N684	Pin—1/16 Cotter	1
11A259	Washer	1
11A260	SHAFT ASSEMBLY — CAMSHAFT DRIVE UPPER	1
11A257	Shaft	1
11A321	Key	1
11A258	End Piece	1
25N2394	Pin—⅛ Diameter	1
11D77	Housing—Upper Drive	1
11A270	Gasket—Upper Drive Housing to Cylinder Head	1
11B224	Housing—Camshaft Drive Intermediate 6" Long.....	1
11N489	Screw—¼—28	1
V–1076A	Screw—¼—28	5
V–1107	Washer—¼ Plain	4
V–1636	Washer—¼ Lock	10
11A284	Shim—.003	•
11A284–1	Shim—.005	•
11A284–2	Shim—.010	•
11A284–3	Shim—.020	•
11N748	Shim—.0063	•
11N749	Shim—.0125	•
11N751	Shim—.025	•
11N755	Shim—.050	•
11N765	Shim—.080	•
V–1209	Gasket—Upper Camshaft Housing	1
11N865–1	CAMSHAFT DRIVE ASSEMBLY—UPPER RIGHT BANK Same as 11N865 Except the Following Parts:	
11D77–1	In Place of 11D77.....	1
11B224–1	In Place of 11B224.....	1

Camshaft Lower Drive

11A256	DRIVE ASSEMBLY—CAMSHAFT LOWER & FUEL PUMP	2
11A255	Spacer	2
11B374	Gear	2
V–1486	Shaft—Left Bank	1
V–1486–1	Shaft—Right Bank	1

Part No.	Description	No. Reqd. per Engine
V–1472	Retainer—Bearing	1
11N541	Plate—Left Bank	1
V–1271	Gasket	2
V–1178	Container	2
V–1212	Spacer	2
V–1128	Pin—⅛ Cotter x 1"	2
V–1211	Nut	2
V–1122	Key	4
V–1630	Shim	*
V–1631	Shim	*
V–1632	Shim	*
V–1172	Ball Bearing	4
25N2464	Nut—¼—28 Plain	8
V–1107	Washer—¼ Plain	8

Camshaft Pressure Oil Tube

11C331	TUBE—PRESSURE OIL TO CAMSHAFT.	1
11N737	Flange	2
11B330	Tube	1
11B330–1	Tube	1
11W1047	Tee	1
25N2464	Nut—¼—28 Plain	2
V–1636	Washer—¼ Lock	6
11N717	Lock Wire (.042)	2
11N718	Bolt—¼—28	4

Carburetion

11W1087–E	CARBURETION—COMPLETE ASSEMBLY	1
11W1086	Yoke - Carburetor Shaft Adjusting	3
11N659	Bolt	3
V–1107	Washer—¼ Plain	35
11N687	Pin—1/16 Cotter	3
25N2457	Nut—¼ Slotted	3
11N717	Lock Wire (.042)	6
11N732	Screw	6
11N680	Nut—10—32 Plain	6
11N745	Nipple	1
11N744	Nipple	2
11N686	Pin—1/16 Cotter	2
11N777	Pin—Clevis	1
11N723	Screw	15
11N675	Washer—3/16 Plain	19
11N678	Washer—#12 Lock	19
11A722	Screw	4
11A681	Nut—12-24 Plain	4
V–1676	Nut—5/16—24 Plain	8
11N672	Washer—5/16 Plain	8
11N679	Washer—5/16 Lock	8
11A279	Gasket	2

* As Required

Part No.	Description	No. Reqd. per Engine
11N527	Carburetor (Refer to Illustration Pg. 4-0)	2
25N2464	Nut—¼ Plain	24
V–1636	Washer—¼ Lock	24
11A281	Gasket	4
11W1100	SHAFT ASSEMBLY — CARBURETOR THROTTLE CONNECTION	1
11W1089	Lug-Carburetor Throttle Con-Container Shaft	3
11W1101	Shaft-Carburetor Throttle Control Rod	1
11W1080	TUBE ASSEMBLY—FUEL FEED	1
11N738	Nut	2
11N740	Cone	2
11C614	Tube — Carburetor to Carburetor Fuel—Long	1
11A615	Tube — Carburetor to Carburetor Fuel—Short	1
11C359	AIR CLEANER ASSEMBLY	1
11N731	Screw	8
V–1636	Washer—¼ Lock	8
11W1078	Flange-Air Cleaner to Air Scoop Manifold	1
11W1075	TUBE ASSEMBLY — INTAKE "Y" MANIFOLD TO INTAKE "Y" MANIFOLD WATER	1
11W1074	Tube—Intake "Y" Manifold to Intake "Y" Manifold Water	1
25B2787	Cross—Water Tube Connection	1
11N739	Nut—½ Tube	2
11N741	Cone—½ Tube	2
11N512	Fitting	2
11N513	Fitting	1
11W1062	INTAKE "Y" MANIFOLD ASSEMBLY	2
11W1060	Manifold—Intake	2
11N745	Nipple	2
11N669	Stud	12
11N790	Nipple	1
11W1077	AIR SCOOP ASSEMBLY	
25N2567	Plug—¼ Pipe	
V–1687	Bushing	8
11N670	Plug—Welch	1
11W1076	Manifold — Air Scoop — Carburetor	1
11W1088	ASSEMBLY—INTAKE "L" MANIFOLD.	4
11N669	Stud	11
11W1061	Manifold Intake "L"	4
11W1081	Tube — Inlet "T" to Manifold Connection R.H.	1
11C617	Tube—Fuel Pump to Carburetor.	1

Connecting Rod

Part No.	Description	No. Reqd. per Engine
11W1048	ROD ASSEMBLY — MASTER & LINK CONNECTING	6
11W1007	ROD ASSEMBLY—LINK CONNECTING	6
11A155	Bushing	12
11W1012	Rod—Link Connecting	6
11A154	Bushing	6
11C1006	ROD ASSEMBLY — MASTER CONNECTING	6
11A356	Rod—Master Connecting Bolt	6
11W1011	Rod—Master Connecting Bolt	24
11W1010	Cap	6
11N701	Pin—Cotter	24
11A154	Bushing	6
11N782	Nut—3/8 Slotted	24
11A663	Rivet—Countersunk Head	24
11B349	Bearing—Lower	6
11B349-1	Bearing—Upper	6
11W1096	LINK PIN ASSEMBLY	6
11W1098	Tube	12
11W1095	Pin	6
11N726	Nut—3/8 Slotted	6
11N701	Pin—Cotter	6
11W1102	Bolt—Link Pin Lock	6
11W1059	Piston	12
11W1031	Pin—Piston	12
11W1013	Ring—Piston Pin Retainer	24
11B322	Ring—Piston Lower	12
11B323	Ring—Piston	24

Crankcase

11N469	CRANKCASE AND REVERSE GEAR HOUSING ASSEMBLY	1
11E245	CRANKCASE ASSEMBLY — LOWER HALF	1
11E2	Crankcase—Lower Half	1
11A190	Bushing	8
11A189	Bushing	4
11A40	Stud	4
11A130-2	Stud	5
11N462	Plug—3/4 Pipe	2
11A71	Seat—Valve	1
V-358-A	Valve	1
11A285	Spring	1
11A70	Guide—Valve	1
V-361-A	Gasket	1
11A169	Bushing—Screw	6
11A132	Bearing	2
11A47	Stud	4
11N440	Dowel	2
V-1124	Plug—Pipe	1
11A130-1	Stud	4
11N413	Dowel	2
11A149	Dowel	8
11N400	Pin—Dowel	6
V-2054	Plug—Pipe	3
11C55	Tube	1
V-1120	Gasket	1
11A230	Stud	2
25A537	Gasket	2
11A56	Plug	2
11A130	Stud	28
11N787	Reducer	1
11A160	Stud	2
11E122	Housing—Reverse Gear—Lower	1
V-1190	Screw	1
11A59	Washer—Bearing Bolt	16
V-2041	Nut—1/2—20 Plain	4
11A243	Ring	1
25N2461	Nut—1/2—20 Slotted	16
11B347	Bearing—Main	2
11B348	Bearing—Main	6
V-1105	Pin—3/32—Cotter	16
11N514	Fitting	1
V-386-A	Nut—3/8—24 Plain	14
25N2478	Nut—7/16—20 Plain	4
V-1107	Washer—1/4 Plain	6
V-1109	Washer—3/8 Plain	32
V-3024	Washer—7/16 Plain	4
V-1683	Washer—1/2 Plain	8
V-1636	Washer—1/4 Lock	6
V-1638	Washer—3/8 Lock	14
V-1640	Washer—1/2 Lock	2
11E207	CRANKCASE ASSEMBLY—UPPER HALF	1
11E3	Crankcase—Upper Half	1
11N425	Nipple	2
11A161	Stud	3
11A189	Bushing—Screw	4
11A124	Stud	2
11A125-1	Stud	2
11A124-1	Stud	9
11A125	Stud	2
11N400	Dowel	6
11B52	Shaft	1
11A202	Stud	4
11A201	Stud	8
V-1124	Plug—Pipe	1
11A47	Stud	4
11A149	Dowel	8
11B58	Bolt	16

Part No.	Description	No. Reqd. per Engine
11A204	Stud	40
11A200	Stud	2
11A203	Stud	16
11A164	Stud	4
25N2461	Nut—½ Slotted	16
V–1105	Pin—3/32 Cotter	16
11A59	Washer	16
11B347-1	Bearing—Main	1
11B347-2	Bearing—Main	1
11B348-1	Bearing—Main	6
11N453	Bolt—⅜—24	14
11N452	Bolt—⅜—24	3
11A57	Bolt—Engine Lifting	4
11B162	Plate—Governor Drive	1
11A163	Gasket—Governor Plate	1
11A276	Gasket—Two Bolt Type	1
V–386–A	Nut—⅜—24 Plain	4
25N2478	Nut—7/16—20 Plain	3
V–1109	Washer—⅜ Plain	4
V–3024	Washer—7/16 Plain	3
V–1638	Washer—7/16 Lock	6
V–1639	Washer—⅜ Lock	3
V–1640	Washer—½ Lock	2
11D263	HOUSING ASSEMBLY—REVERSE GEAR —UPPER	1
11N522	Seal	1
11A357	Bushing	1
11A190	Bushing—Screw	4
11A191	Bushing	2
11A170	Stud	10
11A170-1	Stud	4
11A251	Indicator	1
11E123	Housing—Reverse Gear Upper	1
V–2103	Bolt—⅜—24	5
V–2063	Bolt—⅜—24	4
V–1109	Washer—⅜ Plain	20
V–1638	Washer—⅜ Lock	24
V–386–A	Nut—⅜—24 Plain	12
11N429	Bolt—½—20	2
11N424	Bolt—⅜—24	4
25N2441	Bolt—⅜—24	4

Crankshaft Assembly

11C264	CRANKSHAFT ASSEMBLY	1
11A180	Plug	1
11B181	Spacer	1
11B76	Gear	1
11C63	Crankshaft	1
11N459	#4 Taper Pin	1
11N783	Bolt—5/16—24	1
25N2458	Nut—5/16—24	3
11N730	Bolt—5/16—24	2
11W1085	Plug	6
11W1020	Tube	6
11W1043	Tube	1
11B42	Gear—Crankshaft Timing	1

Cylinder Assembly

11W1041	CYLINDER HEAD ASSEMBLY — LEFT BANK	1
11N683	Gasket	4
11A650	Nut—⅜ Plain	58
V–1638	Washer—⅜ Lock	58
11N673	Washer—⅜ Plain	58
11N734	Stud	10
11C278	Gasket	1
11B271	Head—Cylinder	1
11N669	Stud	2
25N2458	Nut—5/16 Slotted	12
11N672	Washer—5/16 Plain	12
11N733	Stud	12
11N717	Lock Wire—.042	2
11N666	Pin—Dowel	13
11N655	Bushing	6
11N735	Stud	20
11W1003	Screen	3
11W1004	Lock Wire	3
11W1028	Gear	1
11W1029	Plug	1
11N665	Bushing	24
11N668	Stud	73
11B396	Packing	6
11W1068	Jacket—Water	1
11C647	Sleeve	6
11W1023	Bushing	12
11W1021	Ring	24
11B1099	Valve—Intake and Exhaust	24
11W1039	Guide	24
11W1056	Spring—Inner	24
11W1057	Spring—Outer	24
11A1001	Bushing	24
11W1002	Washer	24
11N719	Pin	24
11A602	Plug	6
11A394	Nut	6
11A601	Bushing	12
11B609	Retainer	12
11B318	Retainer	6
11B317	Packing	6
11N687	Pin—1/16 Cotter	6
11N664	Bushing	2
11N651	Bushing	2

Part No.	Description	No. Reqd. per Engine
11A395	Pin	12
11W1084	PLUG ASSEMBLY—CYLINDER HEAD—LARGE	4
11W1022	Spider	4
11W1083	Plug	4
11N676	Washer—5/16 Plain	4
11N727	Screw—5/16—24	4
11B128	Gasket—Intake Manifold to Cylinder Head	4
11C280	Gasket—Valve Cover	2
11B282	Gasket—Exhaust Manifold to Cylinder Head	4
11C129	Gasket—Water Jacket to Crankcase	2
11A275	Gasket—Two Bolt Type	2
11A277	Gasket—Two Bolt Type	24
11N718	Bolt—1/4—28	4
V-1676	Nut—5/16—24 Plain	46
V-1107	Washer—1/4 Plain	48
V-1636	Washer—1/4 Lock	34
25N2464	Nut—1/4 Plain	44
11W1044	CYLINDER ASSEMBLY—RIGHT BANK. All parts the same as under 11W1041, except the following part:	1
11B271-1	Head Cylinder in place of 11B271	1

Distributor

11C111	HOUSING ASSEMBLY—DISTRIBUTOR—UPPER	1
V-1676	Nut—5/16 Plain	4
V-1637	Washer—5/16 Lock	4
V-1108	Washer—5/16 Plain	4
25A1554	Washer	2
25N2459	Nut—3/8 Slotted	2
V-1105	Pin—3/32 Cotter	2
V-1658	Key	2
11B627	Gear	2
11N419	Distributor (Refer to Illustration Pg. 4-P)	2
11N591	Ignition—Rotor	2
11N419-1	Breaker Points	4
11N419-2	Breaker Lever	4
11N419-3	Contact & Support—Lower	2
11N419-4	Contact & Support—Upper	2
11B110	STUD ASSEMBLY—UPPER DISTRIBUTOR HOUSING	1
11A107	Stud	4
11E103	Housing	1
11N461	Bearing	1
11N545	Bolt—Upper Housing to Lower Housing	9
V-2047	Screw—Upper Distributor Housing to Lower Distributor Housing	1
11N509	Screw—Distributor Oil Supply Tube Flange	2
11A275	Gasket—Two Bolt Type	1
11B333	Gasket	1
11B638	STUD ASSEMBLY—LOWER DISTRIBUTOR HOUSING	1
11A105	Stud	4
11E104	Housing	1
11A82	Bushing	1
11N498	Dowel	2
11A248	Gasket—Distributor Lower Housing to Bearing Housing	1
V-1683	Washer—Distributor Lower Housing to Crankcase	4
25N2461	Nut—1/2—20 Slotted	4
V-1676	Nut—5/16—24 Plain	9
V-1108	Washer—5/16 Plain	17
V-1637	Washer—5/16 Lock	10
11B625	SHAFT & GEAR ASSEMBLY—DISTRIBUTOR DRIVE	1
11A113	Gear	1
11B626	Shaft	1
11A115	Spacer	1
11B375	TUBE ASSEMBLY—DISTRIBUTOR OIL	1
11B358	Tube—Distributor Oil	1
11N737	Flange—Distributor Oil Tube	1
11N788	Tube—Approximately 18" Long	1
V-1869A	Bracket	1
V-1107	Washer—1/4 Plain	2
V-1636	Washer—1/4 Lock	2
11N792	Tee	1

Electrical Equipment

11N465	Fuse Block	1
11N465-1	Fuse—40 Amperes	1
11N445	Regulator—Voltage	1
V-1625	Relay—Starter	1
11N466	Switch—Starter	1
V-3187	Ammeter	1
11N446	Switch—Master Cut Out	1

Exhaust Manifold

11A616	EXHAUST MANIFOLD & ELBOW ASSEMBLY—RIGHT HAND	1
11E619	Manifold—Exhaust	1
11A344	Elbow	2

Part No.	Description	No. Reqd. per Engine
11N456	Bolt—5/16—24	6
V–1637	Washer—5/16 Lock	6
V–1676	Nut—5/16 Plain	6
11A346	Gasket	2
11A345	Plate	2
V–2054	Plug—Pipe	2
11A616–1	EXHAUST MANIFOLD & ELBOW ASSEMBLY—LEFT HAND	1
11E619–1	Same as 11A616 except following: In Place of 11E619	1
25N2464	Nut—1/4 Plain	56
V–1636	Washer—1/4 Lock	56
11N539	Hose—1 1/4 I.D.	5
25N2390	Clamp—Hose	10
11B620	Gasket—Exhaust Manifold Flange	2

Fresh Water Pump

11C234	PUMP ASSEMBLY—FRESH WATER	1
11B370	SEAL ASSEMBLY	1
11N439	Seal	1
11A313	Washer	1
11B238	Impeller	1
11A802	Key	1
V–3037–A	Nut	1
11A237	Spacer	1
11B236	Shaft	1
11A235	Retainer—Bearing	1
V–3027–A	Bearing	1
V–3022–B	Gear	1
11N436	Nut—7/16—20 Shear	1
V–3024	Washer—7/16 Plain	1
11A242	Plate	1
11D206	Body	1
V–1115–A	Stud	8
V–3039–B	Gasket	1
V–1272	Gasket — Pump to Lower Distributor Housing	1
11N438	Ball Bearing	1
V–1208–A	Plug	1
V–3020	Gasket	1
V–1100–A	Nut—1/4—28 Slotted	8
11N542	Cover	1
V–1107	Washer—1/4 Plain	8
V–1103	Pin—1/16 Cotter	8
	Lockwire	†
V–1313	Shim—Thin	*
V–1651	Shim—Thick	*
V–1652	Shim—Medium	*
V–1109	Washer—3/8 Plain	4

Part No.	Description	No. Reqd. per Engine
V–1638	Washer—3/8 Lock	4
11N539	Hose—1 1/4	2
25N2390	Clamp—Hose	4
25N2380	Hose	1
25N2389	Clamp—Hose	2

Fuel Pump

11N921	DRIVE ASSEMBLY—FUEL PUMP	1
V–1103	Pin—1/16 Cotter	7
V–1107	Washer—1/4 Plain	3
V–1108	Washer—5/16 Plain	4
V–1140	Nut—1/4—28 Slotted	3
V–1175	Nut—Fuel Pump Drive Housing Packing	2
V–1176	Packing—Fuel Pump Drive Housing Packing Nut Felt	2
V–1492	Gear & Shaft—Fuel Pump Drive	1
V–1493	Spacer—Ball Bearing	1
V–1495	Gasket — Fuel Pump Driveshaft Housing	1
V–2029	Housing—Fuel Pump Drive	1
V–2031	Shim—Medium	*
V–2032	Shim—Thin	*
V–2033	Shim—Thick	*
V–2035	Ball Bearing—Fuel Pump Drive Gear & Shaft	2
V–2036	Gasket—Fuel Pump Drive Shaft Housing Plate	1
V–2037	Gasket—Fuel Pump Drive Flange	1
V–2038	Stud—Housing to Container	3
11N456	Bolt—5/16—24 Hex. Head—for V–2034 & V–2030	4
V–1676	Nut—5/16—24 Slotted	4
V–2042	Nut—Fuel Pump Drive Gear & Shaft	1
11A608	Container	1
11N478	Pump—Fuel	1
11N515	Fitting	1
11N566	Fitting	1
V–3104A	Fitting	1
V–1649	Pump—Wobble	1
11N499	Filter	1
11N589	Gasket Filter	1
11N590	Gasket Filter	1

Generator

11B390	GENERATOR ASSEMBLY	1
11B819	Gear	1
11A643	Washer	1

† Approximately 5 inches
* As Required

Part No.	Description	No. Reqd. per Engine
25N2453	Nut	1
11N444–2	Pin—Cotter	1
11N444–4	Key	1
11A373	Screen	2
11N444	Generator (Refer to Illustration page 10)	1
11B371	Screen	1
11N449	Screw	4
11A642	Washer—Large	1
11N444–5	Brush Rigging	1
11N444–6	Brush	2
11N444–7	Fuse	2
11N444–8	Bearing	2
11N444–9	Armature	1
11A39	GOVERNOR AND GENERATOR DRIVE GEARS ASSEMBLY (Optional)	1
11B51	Gear	1
11N420	Rivet	6
11A165	Gasket—Generator Flange	1
11C53	Gear—Generator Idler	1
V–1172	Bearing—Ball	2
11N422	Nut—Lock	1
11N423	Washer—Lock	1
V–2086	Oil Cup	1
11A49	Ring—Snap	1
11A50	Spacer—Idler Shaft	1

Heat Exchanger

11E293	HEAT EXCHANGER	1
25B1247	Ring—Packing	1
25N2563	Bolt—5/16—24	12
11C301	Cover	2
11B300	Header	1
11E293–2	Tube—Copper	301
11A299	Baffle	7
25N2480	Nut—5/16 Plain	24
V–1637	Washer—5/16 Lock	24
V–2054	Plug—3/8 Pipe	4
11N495	Bolt—5/16—24	12
25B1248	Gasket	2
11B364	Header—Flanged	1
11D305	HOUSING ASSEMBLY — HEAT EXCHANGER	1
11C306	Flange	2
11D305–1	Housing	1
25N2383	Hose—1 3/4 I.D.	1
25N2389	Clamp—Hose	2

Ignition Equipment

11N447	Coil—Ignition	2
25N2257–58	Terminal—High Tension	26
25N2257–59	Grommet—Rubber Terminal	26
11N448–S	Plug—Spark	24

Oil Cooler

11E295	OIL COOLER ASSEMBLY	1
11E295–2	Tube	301
25N2563	Bolt—5/16—24	12
25N2480	Nut—5/16 Plain	24
V–1637	Washer—5/16 Lock	24
V–2054	Plug—3/8 Pipe	4
11B300	Header	1
25B1247	Gasket—Neoprene	1
11A299	Baffle	9
11B364	Header—Flanged	1
11C301	Cover	2
11N495	Bolt—5/16—24	12
25B1248	Gasket	2
11D296	HOUSING ASSEMBLY—OIL COOLER	1
11C297	Flange	2
11D296–1	Housing	1
11N559	Hose	2
25N2383	Hose—1 3/4 I.D.	2
25N2390	Clamp—Hose	4
25N2389	Clamp—Hose	4

Oil Filter

11N460	Filter—Oil	1
11B166	Adapter—Oil Filter to Crankcase	1
11A167	Gasket—Adapter to Crankcase	1
11A168	Gasket—Adapter to Oil Filter	1
11N493	Screw—Oil Filter to Crankcase	6

Oil Pan

11D95	OIL PAN ASSEMBLY	1
11N400	Dowel	2
11N413	Dowel	1
11A86	Gasket	1
11A90	Stud	4
25N2458	Nut—5/16 Slotted	6
V–1108	Washer—5/16 Plain	6
11A99	Clip	2
11A91	Stud	2
11A84	Gasket	1
11A82	Bushing	3
11E94	Pan—Oil	1
V–2054	Plug—3/8 Pipe	1
	Lockwire .046 x 7" Approximate Length	2
	Lockwire .046 x 4" Approximate Length	1
11C89	TUBE & SUPPORT ASSEMBLY	1
11B85	Support	1

Part No.	Description	No. Reqd. per Engine
11B87	Tube	1
11B88	Tube	1
11A83	Support	1
11A93	Support	1
25A1167	Screen	1
11B223	Gasket—Scavenging Oil Pump to Oil Pan	1
V-1676	Nut—5/16—24 Plain	37
V-1637	Washer—5/16 Lock	37
V-1108	Washer—5/16 Plain	37
11D96	Gasket—Oil Pan to Crankcase	1
	Oil Pump—Pressure	
11C24	OIL PUMP ASSEMBLY—PRESSURE	1
V-358-A	Valve	1
V-361-A	Gasket	1
11A38	Locknut	1
11A36	Guide—Valve	1
11A646	Spring	1
11A31	Gear—Driving	1
11B29	Shaft—Driving	1
11N409	Dowel	1
11A27	COVER ASSEMBLY	1
11C26	Cover	1
25N2567	Plug—1/4 Pipe	1
11A28	BODY ASSEMBLY — PRESSURE OIL PUMP	1
11E25	Body	1
11A30	Bearing	1
11N412	Dowel	2
11A32	GEAR ASSEMBLY	1
11A33	Gear	1
11A34	Bearing	1
V-1639	Washer—7/16 Lock	+
11N559	Hose	1
25N2390	Clamp—Hose	2
11B41	Gasket—Oil Pump to Crankcase	1
V-2047	Screw—Oil Pump to Crankcase	3
11N487	Screw—Oil Pump to Crankcase	2
V-3024	Washer—7/16 Plain	+
25N2478	Nut—7/16 Plain	+
11A546	Inlet	1
11N563	Nipple—3/4 Close	1
11N564	Nipple—1"	1
11N565	Nipple—3/4	1
11B854	Shim—Pressure Oil Pump—.005	*
11B854-1	Shim—Pressure Oil Pump—.010	*
11B854-2	Shim—Pressure Oil Pump—.015	*

* As Required

Part No.	Description	No. Reqd. per Engine
	Oil Pump—Scavenging	
11C208	PUMP ASSEMBLY—SCAVENGING OIL	1
11A334	Screen	1
11A216	Gear—Lower Drive	1
11A215	Gear—Upper Drive	1
11B214	Shaft—Driving	1
V-2170	Washer—Lock	3
11N510	Screw—Cap	3
25N2458	Nut—5/16 Slotted	6
V-1108	Washer—5/16 Plain	6
	Lockwire — 1/16 (approximately 18" long)	
11A212	HOUSING ASSEMBLY—LOWER	1
11E213	Housing—Lower	1
11A319-1	Stud	2
V-2054	Plug—3/8 Pipe	3
11N432	Shaft — Scavenging Oil Pump Idler (Long)	1
11N433	Shaft — Scavenging Oil Pump Idler (Short)	1
11A217	GEAR ASSEMBLY—DRIVEN—	3
11A218	Gear	3
11A219	Bearing	3
11A220	PLATE ASSEMBLY—SEPARATOR	1
11B221	Plate—Separator	1
11N548	Dowel	2
11A241	Bushing	1
11A209	HOUSING ASSEMBLY—UPPER	1
11A211	Bearing	1
11D210	Housing—Upper	1
11A319	Stud	1
11A319-1	Stud	3
V-1637	Washer—5/16 Lock	3
11N559	Hose	1
25N2390	Clamp—Hose	2
V-1108	Washer—5/16 Plain	5
V-2047	Screw—5/16—24	3
V-1637	Washer—5/16 Lock (Lockwire — 1/16 — approximately 7" long)	3
11N487	Screw—5/16—18	2
	Priming System	
11W1108	PRIMING SYSTEM	1
11N517	Elbow	2
11N785	Tee	2
11N786	Tee—Union	1
11W1082	TUBE ASSEMBLY—PRIMING	1
11N742	Nut—Union	2

Part No.	Description	No. Reqd. per Engine
11N746	Cone	2
11W1106	Tube	1
11W1107	TUBE ASSEMBLY—PRIMING	1
11N742	Nut—Union	2
11N746	Cone	2
11W1081	Tube	1
11W1093	TUBE ASSEMBLY—PRIMING	1
11N742	Nut—Union	2
11N746	Cone	2
11W1094	Tube	1
V–1687	Coupling	2
V–1124	Plug—⅛ Pipe	1
11N480	Pump—Priming	1

Reverse Gear Assembly

11K260	Stud—Brake Band Balance Adjusting	1
11G256–T	Nut—for 11K260	1
11K262	Washer—For 11K260	1
11K255–S	Stud—Brake Band Support	1
11K256	Nut—For 11K255–S	1
11K258	Support—For 11K255–S	1
11K234	Drum—Brake	1
11B158	Gasket—Hand Hole Cover	1
11K254	Spring—Brake Band	1
11K251	Pin—Brake Band Support	1
11K252	Bracket—Brake Band Support Pin	2
11K250–S	Brake Band	1
11K249	Lining—Brake Band	1
V–1109	Washer—⅜—Plain	24
V–1638	Washer—⅜—Lock	24
11A229	Gasket—Scavenging Oil Tube Support	1
V–386–A	Nut—⅜—24—Plain	12
11N424	Bolt—⅜—24	6
25N2459	Nut—⅜—24—Slotted	2
V–1105	Pin—Cotter	2
11A247	Gasket—Timing Hole Cover	1
11A246	Cover—Timing Hole	1
11C810	Coupling—Reverse Gear Shaft	1
V–1676	Nut—5/16—24—Plain	14
V–1637	Washer—5/16—Lock	10
25N2441	Bolt—⅜—24	2
25N2442	Bolt—⅝—24	2
11K275	Screw—Brake Adjusting	1
11K276	Nut—Brake Adjusting Screw Lock	1
11G265	Lever—Forward & Reverse	1
11K277	Pin—Brake Band Plunger	1
11K273	Pin—Brake Lever Support	1
11K271	Support—Brake Lever	1
11K270–B	Lever—Brake	1

Part No.	Description	No. Reqd. per Engine
11K272	Nut—Brake Lever Support	1
11K283	Roller—Brake Lever	1
11K284	Pin—Brake Lever Roller	1
11K280–B	Cam—Brake Lever	1
11K316–C	Shaft—Control	1
11K281–C	Screw—Clamp	1
V–3024	Washer—7/16—Plain	12
V–1639	Washer—7/16—Lock	8
11N468	Bolt—7/16—20	8
11KV327	Shaft—Reverse Gear	1
V–1683	Washer—½ Plain	8
V–1640	Washer—½ Lock	4
V–2041	Nut—½—20—Plain	4
11G245–T	Support—Bell Crank	1
11G240–T	Lever—Bell Crank	3
11K216–C	Gear—Reverse Gear Rear	1
11G246–T	Pin—Bell Crank Support	3
11K274	Pin—Brake Lever Cam	1
11N494	Bearing—Hub Nut	1
11Y212	Cover—Gear Case Rear	1
11Y218	Bearing—Pinion Gear	3
11K219–B	Spider—Reverse Gear	1
11B369	Nut—Crankshaft Hub	1
11Y213	Bearing—Rear Gear	1
11Y217	Gear — Pinion	3
11K215–B	Gear—Reverse Gear Front	1
11Y211	Bearing—Front Gear	1
11KY233	Disc — Driven	6
11KY230	Disc — Driving	7
11A173	Collar — Crankshaft	1
25N2416	Screw — 7/16 — 20	4
	Lockwire 1/16	2
11A381	Washer—Crankshaft Hub Nut	1
11A240	Spacer—Crankshaft Locating	1
11Y221	Stud—Front Gear Case to Drum Case	12
11Y222	Nut—Front Gear Case to Drum Case	12
11K210–B	Case—Front Gear	1
11K236	Plunger—Quick Release	3
11K235	Spring—Clutch Detent	3
11K317	Key—Control Shaft	4
11K282–C	Nut—Clamp Bolt	1
11K311–B	Lever—Clutch Shifter	1
11P312	Screw—Clutch Shifter	2
11G307	Sleeve—Ball Bearing Retainer	1
11G306	Bearing—Clutch Shifter	1
11G304	Bushing—Engaging Spider	1
11G305	Lockwire—Clutch Engaging Spider	1
11Y303	Insert—Shifter Spider	3
11G339	Seal—Rear Oil	1

Part No.	Description	No. Reqd. per Engine
11N535	Bearing—Reverse Gear Shaft	1
11K333-D	Cap—Thrust Bearing	1
11K332-C	Retainer—Thrust Bearing	1
11K335-D	Nut—Ball Bearing	1
11K335-D-W	Washer—Ball Bearing Lock	1
11G315	Yoke—Clutch Shifter	1
25N2458	Nut—5/16—24 Slotted	2
V-1104	Pin — Cotter	2
11G310-T	Spider — Engaging	1
11G301-T	Pin—Bell Crank Lever Link	3
11G243-T	Link—Bell Crank	3
11G239-T	Plunger—Clutch Toggle	3
11Y244	Pin—Roller Lever Stop	3
11K247	Bolt—Clamp	1
11K248	Nut—Clamp	1
11G286-T	Pin—Clutch Engaging Spider	3
11N472	Pin—Cotter	1
11A228	TUBE & SUPPORT ASSEMBLY	1
11B225	Support	1
11A226	Tube	1
11A227	Support—Screen	1
25A1167	Screen	1
11A604	COVER ASSEMBLY — REVERSE GEAR HAND HOLE	1
25A2108	Breather	1
11N536	Screw—1/4—28	2
V-1107	Washer—1/4 Plain	2
V-1636	Washer—1/4 Lock	2
25A580	Gasket—Breather	1
11C159	Cover	1
11B605	CLUTCH HOUSING AND CRANKSHAFT HUB ASSEMBLY—REVERSE GEAR	1
11A606	HOUSING ASSEMBLY	1
11B174	Gear—Flywheel Ring	1
11C382	Housing—Flywheel	1
11C380	Hub—Crankshaft	1
11A383	Bolt—Crankshaft Hub to Clutch Housing	6
25N2462	Nut—5/8—18 Slotted	6
25N2406	Pin—Cotter	6
11A74	Key—Crankshaft	1
V-1108	Washer—5/16 Plain	12
11N547	Bolt—3/4—10	1

Sea Water Pump

11D8	PUMP ASSEMBLY—SEA WATER	1
11N504	Seal—Oil	2
V-1659	Key	2
11B19	Gear—Driven	1
V-1105	Pin—3/32 Cotter	2
25N2461	Nut—1/2 Slotted	2
11A18	Washer	2
11B17	Gear—Driving	1
11A16	Ring—Snap	2
V-1170	Bearing—Ball	2
11N407	Screw—5/16—18	4
11N408	Screw—5/16—18	4
11A20	Gasket	2
11B21	Inlet	2
11B14	Gasket	1
25N2443	Screw—5/16—18	8
V-1637	Washer—5/16 Lock	16
V-1108	Washer—5/16 Plain	16
11A634	Shim .002 Thick 2 I.D.	*
11A634-1	Shim .005 Thick 2 I.D.	*
11A635	Shim .002 Thick 13/16 I.D.	*
11A635-1	Shim .005 Thick 13/16 I.D.	*
11A10	BODY ASSEMBLY	1
11E9	Body	1
11N400	Dowel	2
11B15	Impeller	1
11B15-1	Impeller	1
11N463	Seal	2
11A316	Washer	2
11A352	PLATE ASSEMBLY—END	1
11C350	Plate—End	1
11A351	Bushing	2
11B23	Gasket—Pump to Crankcase	1
V-386-A	Nut—3/8—24 Plain	8
V-1109	Washer—3/8 Plain	8
V-1638	Washer—3/8 Lock	8
25N2383	Hose—1 3/4 I.D.	3
25N2389	Clamp—Hose	6
11B43	Shaft—Sea Water Pump Drive Coupling	1
V-1657	Plug—1/8 Pipe	2
V-504A	Washer—Leather	2

Shielding

11E816	ASSEMBLY RADIO SHIELDING	1
11D831	ASSEMBLY DISTRIBUTOR SHIELD	1
11B846	SHIELDING—IGNITION COIL	2
11N570	Ferrule	6
11N581	Screw—Self Tapping	8
11N574	Screw—10—32	8
11N575	Nut—10—32	8
25N2767	Lockwasher—#10	8
11C823	Bracket—Support	2
11N573	Screw—3/8—24	4
V-1638	Lockwasher—3/8	4
11N908	Screw—5/16—18	4
11D830	SHIELD—STARTER RELAY	1

* As Required

Part No.	Description	No. Reqd. per Engine
11N570	Ferrule	2
11N571	Ferrule	2
11N581	Screw—Self Tapping	8
11N574	Screw—10—32	4
11N575	Nut—10—32	4
25N2767	Lockwasher—#10	4
11C821	Bracket	1
11N573	Screw—⅜—24	2
V–1638	Lockwasher—⅜	4
11N572	Screw—⅜—24	2
11N928	Clip	1
11C829	SHIELD—VOLTAGE REGULATOR	1
11N570	Ferrule	3
11N580	Screw—Self Tapping	8
11N574	Screw—10—32	10
11N575	Nut—10—32	10
11C822	Bracket	1
25N2767	Lockwasher—#10	10
11N573	Screw ⅜—24	2
V–1638	Lockwasher—⅜	2
11N580	Screw—6—32	2
11A834	SHIELDING—STARTER	1
11N571	Ferrule	1
11N581	Screw—Self Tapping	2
11N904	Screw—8—32	2
11A833	SHIELD—GENERATOR	1
11N570	Ferrule	2
11N904	Screw—8—32	2
11N581	Screw—Self Tapping	3
11E816–1	Tube—Intake	1
11A824	Clamp	2
11A825	Clamp Base	2
11N576	Screw—¼—20	4
V–1150	Nut—¼—28	4
V–1115	Stud	4
V–1636	Lockwasher—¼	8
11N922	Gasket	12
11E816–2	Tube—Exhaust	2
11N723	Screw—12—24	4
11E816–2–1	Clip	4
11N678	Lockwasher—No. 12	4
11N922	Gasket	12
11C832	SHIELDING—INSTRUMENT PANEL	1
11N570	Ferrule	5
11N581	Screw—Self Tapping	6
11N918	Washer	2
11N915	Nut	5
11N916	Ferrule	5
11N917	Washer	3
11N583	Elbow—Spark Plug	24

Part No.	Description	No. Reqd. per Engine
11N574	Flexible Tubing 1—¼ I.D.	1
11N585	Flexible Tubing 1—I.D.	2
11N586	Flexible Tubing—¼ I.D.	12
11N910	Flexible Tubing—¼ I.D.	12
11N909	Flexible Tubing—¼ I.D. x 10 inches long	2
11N911	Flexible Tubing—¼ I.D. x 27 inches long	4
11N933	Clip	2
11R934	Clip	2
11N901	Cable — No. 0 Starter Motor to Starter Relay	‡3
11N902	Cable—No. 8 Low Tension	*
11N903	Cable—No. 12 Low Tension	*
11N906	Tubing—¾ I.D.	1
11N912	Terminal—Whitaker No. 827	3
11N923	Gasket	4
11N925	Ignition Cable—Spark Plug Terminal	*
11N926	Gasket	4
11N927	Gasket	2
11N929	Nipple—Coil	2
11N930	Terminal—H. T. Coil	2
11N931	Marker—1L to 6L	§2
11N932	Marker—1R to 6R	§2
11N592	Terminal No. 0 Cable	3
11N593	Terminal No. 8 Cable	2
11N595	Terminal No. 12 Cable	27
11N597	Sleeve—Contact	24
11N598	Collar—Sleeve	24
11N935	Nut	2
11N936	Screw	2

Starter Motor Housing

11A102	HOUSING ASSEMBLY—STARTER MOTOR	1
25A2108	Breather	1
25A569	Stud	2
11E97	Housing	1
25N2464	Nut—¼ Plain	2
V–1107	Washer—¼ Plain	2
V–1636	Washer—¼ Lock	2
25A580	Gasket	1
V–1623	Starter Motor (Refer to Illustration page 9)	1
11B148	Gear—Starter Motor Pinion	1
11C98	Gasket—Starter Motor Housing to Crankcase	1
11N491	Screw—Starter Motor Pinion Gear	1
V–145–A	Washer—Starter Motor Pinion Gear	1

* As Required ‡ Inch. § Sets.

Part No.	Description	No. Reqd. per Engine
V–1676	Nut—5/16—24 Plain	11
V–1108	Washer—5/16 Plain	11
V–1637	Washer—5/16 Lock	12
V–1659	Key	1
V–2677	Bushing—Starter Motor	2
V–2682	Brush—Starter Motor	4
V–2683	Brush—Rigging—Starter Motor	1
V–2694	Armature	1
	Thermostat	
25C2069	THERMOSTAT ASSEMBLY	1
25D2064	Cover	1
25A2272	Thermostat	2
V–1676	Nut—5/16 Plain	6
V–1637	Washer—5/16 Lock	6
V–1108	Washer—5/16 Plain	6
25A2106	Gasket	1
25B2071	HOUSING ASSEMBLY	1
25E2059	Housing	1
25A2072	Stud	6
25N2380	Hose—2 I.D.	4
25N2389	Clamp—Hose	8
	Valve Gear Cover	
11C389	VALVE COVER ASSEMBLY—RIGHT BANK	1
25A2108	Breather—Cylinder Head Cover	1
25A580	Gasket—Valve Breather	1
V–323	Gasket	2
11A388	Elbow—Valve Gear Cover Drain	1
V–321–A	Nut—Lock 7/8—18 U.S.F. x 9/32	1
11A856	Screw — Cap — Valve Cover Breather	2
25N2464	Nut—Valve Cover Breather	2
V–1107	Washer — Plain Valve Cover Breather	2
110603	Cover—Valve Gear	1
V–1636	Washer — Breather Valve Gear Cover	2
11N682	Washer—Tachometer Housing to Valve Cover	1
11N678	Washer — Valve Gear Cover to Cylinder Head Lock	31
11W1065	TACHOMETER ASSEMBLY (For 11C389 only)	1
11W1064	Spring — Tachometer Drive Shaft	1
11N661	Pin—Tachometer	1
11W1067	Shaft—Tachometer Drive	1
11W1046	Collar—Tachometer	1
11W1066	Housing—Tachometer Drive	1
11N677	Washer—Tachometer	1
11C389–1	VALVE COVER ASSEMBLY—LEFT BANK	1
	Same as 11C389 except the following:	
11C603–1	Cover in place of 11C603	1
11N720	Plug in place of 11W1065	1
11N723	Screw — Valve Cover to Cylinder Head	31
11B329	Tube—Valve Gear Cover Drain	1
V–2000	Hose — Valve Gear Cover Drain Tube	2
V–1682	Clamp Hose	8
	Vertical Drive Assembly	
11B817	VERTICAL DRIVE GEAR & BEARING ASSEMBLY	1
11A639	Shim—Vertical Drive Gear	*
11A312	Key — Distributor Lower Drive Gear	2
11B140	Gear—Vertical Drive	1
11A139	Spacer—Accessories Drive Gear	1
11W1030	Gear—Vertical Drive Shaft	1
11N780	Pin—Vertical Drive Shaft Taper	1
11N781	Nut—Vertical Drive Shaft	1
11N684	Pin — Vertical Drive Gear Nut Cotter	1
11D815	SHAFT—VERTICAL DRIVE	1
11N426	Pin—Vertical Drive Shaft	2
11B141	Gear—Water Pump Drive	1
11B146	BEARING HOUSING ASSEMBLY	1
11A145	Bushing—Vertical Drive Shaft	2
11C144	Housing—Vertical Drive Shaft	1
11A248	Gasket — Bearing Housing to Crankcase	2
11A250	Shim—.005	*
11A250–1	Shim—.010	*
11A135	GEAR AND SHAFT ASSEMBLY—LOWER VERTICAL DRIVE	1
11B131	Shaft—Vertical Drive Shaft Oil Pump	1
11W1030	Gear—Vertical Drive Shaft	1
11N781	Nut—Vertical Upper Drive Gear	1
11N780	Pin—Taper Vertical Upper Drive Gear	1
11N684	Pin—Cotter—Vertical Drive Gear Nut	1
11A283	Shim—.003	*
11A283–1	Shim—.005	*

* As Required

Part No.	Description	No. Reqd. per Engine
11A283–2	Shim—.010	*
11A283–3	Shim—.020	*
11D332	TUBE ASSEMBLY WATER INLET—RIGHT BANK	1
11A532	Flange—Water Inlet Petcock	1
11B379	Tube—Water Inlet Manifold	1
11N736	Flange—Water Inlet Manifold	6
11W1032	Tube—Main Water Inlet Manifold	1
11W1016	Nipple—Long	1
11W1017	Nipple—Medium	1
11W1018	Nipple—Short	3
11D355	TUBE ASSEMBLY — WATER INLET — LEFT BANK	1
11A532	Flange—Water Inlet Petcock	1
11B378	Tube—End—Water Inlet	1
11N736	Flange—Water Inlet Manifold	6
11W1034	Tube—Main Water Inlet Manifold	1
11W1016	Nipple—Long	1
11W1017	Nipple—Medium	1
11W1018	Nipple—Short	3
11N521	Petcock	2
11D342	OUTLET ASSEMBLY—WATER—RIGHT HAND	1
11W1036	Nipple—Tube—Short	3
11W1037	Nipple—Tube—Medium	1
11W1038	Nipple—Tube—Long	1
11N736	Flange—Water Outlet Manifold	6
11B628	Tube—End Right Hand and Left Hand	2
11W1071	Tube—Right Hand—Main	1
11A533	Tube—$\frac{3}{8}$ x 7 long	1
11A534	Tube—$\frac{1}{4}$ x $7\frac{1}{4}$ long	1
11N512	Nut	1
11N513	Tee	1
11D342–1	OUTLET ASSEMBLY — WATER — LEFT HAND	1
	Same as 11D342 except the following:	
11W1070	Tube in Place of 11W1071	1
25N2464	Nut—$\frac{1}{4}$—28 Plain	48
V–1636	Washer—$\frac{1}{4}$ Lock	48
11N539	Hose	2
25N2390	Clamp	4

Miscellaneous

11C384–1	INSTRUMENT PANEL—ASSEMBLY	1
11C384	Instrument Panel	1
11A860	Nut—Instrument Panel	2
11A860–1	Sleeve—Instrument Panel	2
11N466	Switch—Push Button	1
11A320	Switch—Ignition	1
V–2403	Gauge—Oil Pressure	1
11N485	Gauge — Temperature (12′) or 11N561 (20′)	2
V–2408	Gauge—Fuel Pressure	1
11D335	Crate—Shipping	1
11A376	Plate—Name	1
11B385	ASSEMBLY—FRESH WATER EXPANSION TANK	1
11N554	Elbow	2
11N556	Rod	2
11N791	Gage—Glass	1
11B385–1	Valve	2
11N550	Screw—$\frac{6}{32}$	10
11N551	Washer—Lock (6-32)	10
11N552	Nut—Plain—Hex. HD. (6-32)	10
V–2199	Tachometer	1
11N560	Casing Assembly—Tachometer Cable	1
11B641–T	Wrench—Crankshaft Hub Nut	1
11N599	Wrench—Spark Plug	1
11N796	Nut—$\frac{9}{16}$—18 Hex.	2
11N798	Cap—Screw—$\frac{9}{16}$—18	2
11N799	Washer—$\frac{9}{16}$	2
11N562	Lockwasher—$\frac{9}{16}$	2
11C812	Angle Iron	2
11N797	Bolt—$\frac{1}{2}$	6

* As Required

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